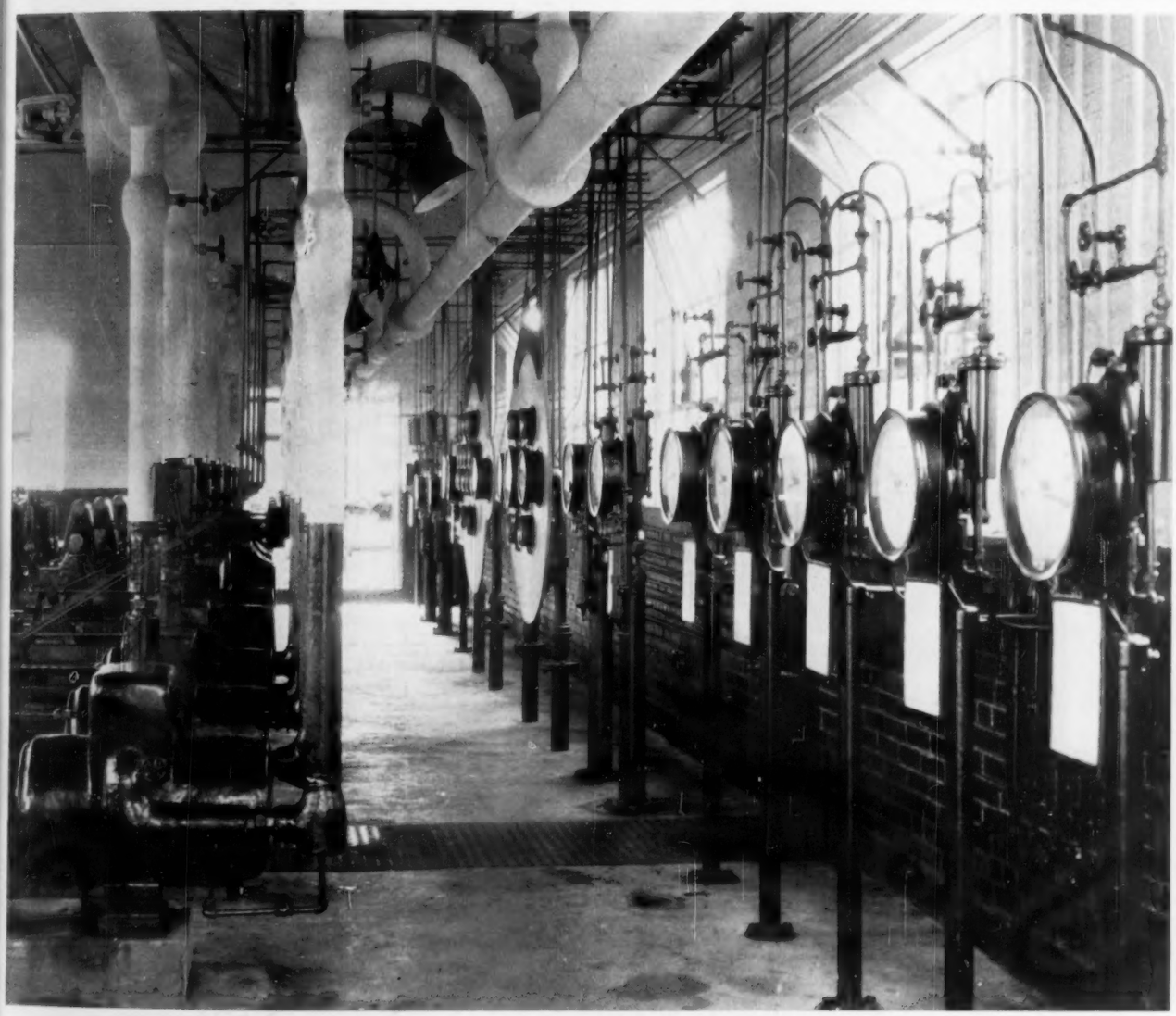
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 5 MARCH, 1932 NUMBER 3



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(See Page 66)

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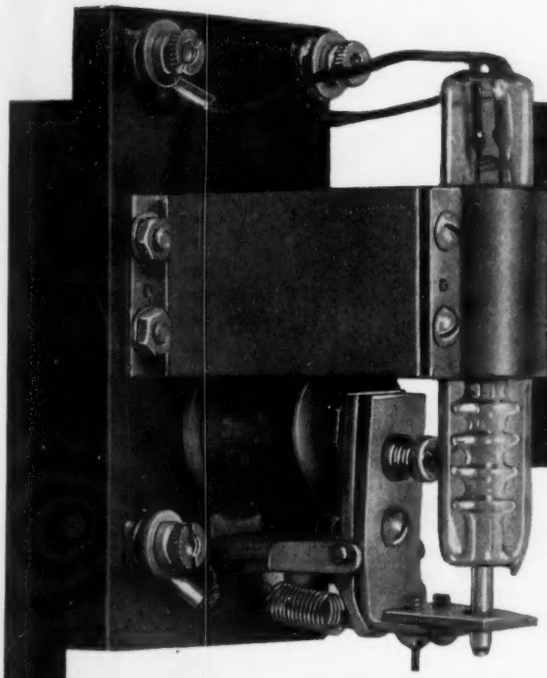

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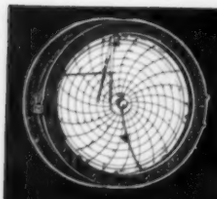

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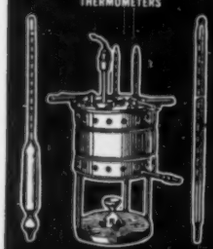

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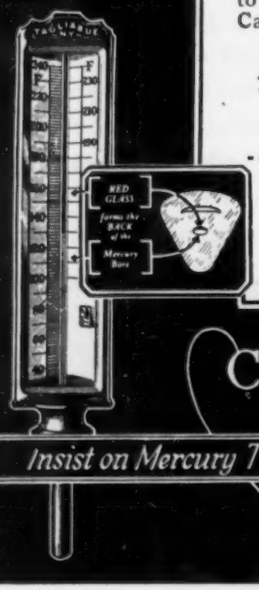

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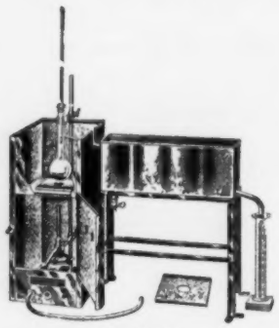

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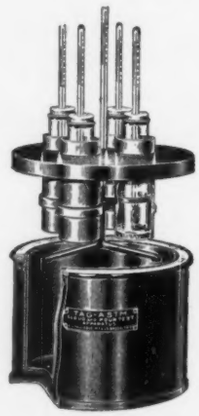

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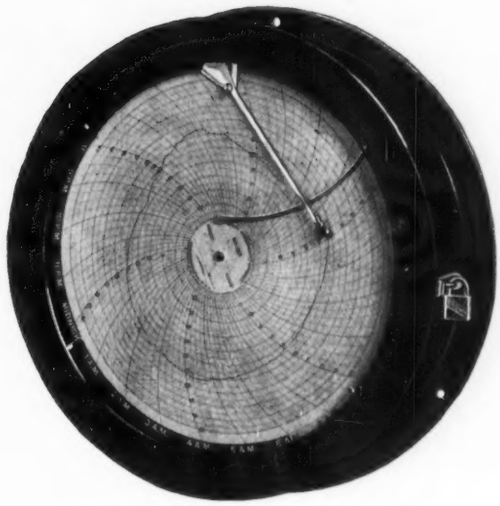
Brown Absolute Pressure Gauge Manometer Transmitter. Part No. 15144.



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EDITORIAL COMMENT

In This Issue

◆ **Telemetering** or the transmission of measurements, amounts to "an extension of the human intelligence." (Apologies to Brown Instrument Co.) Industry in recent years has found vastly increasing need for such extension of human intelligence. The developments in electrical telemetering which have recently been coming rapidly forward to fill this need are outlined in this month's article. Page 66.

◆ In many industries and processes it is necessary to base control upon the study of phenomena that occur in a flash of time, or at very high speeds. High-speed photography, which provides permanent pictures of the phenomena so that they can be studied at leisure, is a valuable means for making these studies. How this tool has been applied to **the study of Diesel Engine Combustion** is set forth in this issue Page 61.

◆ Better and better instruments—whatever makes them so is of basic interest to our readers—hence the article on **Illium.** Page 65.

◆ **Flow Measurement** is the subject of this month's installment of the Manual of **Instrumentation,** which is being published serially in INSTRUMENTS. Page 75.

◆ ◆ ◆

The Front Cover

◆ The front cover is a view of the pump room of the Marcus Hook Plant of the Pure Oil Company.

Under the Surface

IN VIEW of the present sluggishness of business, industry appears on the surface to be stagnant. Under the surface, however, intense activity can be seen. Not production activity, it is true, but the activity of change and improvement—change of processes, change of methods, changes of engineering practice, and improvement of plants and equipment. Alert managers in many industries are taking advantage of this period of slowed-up production to fit their plants for production of new and better products at lower cost.

And in the main this progress is due to a vastly increasing adoption of instruments and automatic controls as basic tools in industry. In the steel industry alone, for example, combustion control mechanisms for open hearth furnaces are coming into extensive application; pyrometers are being widely used in rolling mills to indicate the proper temperature of the bloom for rolling; also there is increasing use of X-rays as a means of determining the internal structure of steel in controlling processes of manufacture or quality of product.

Business may be in a depression, but under the surface industrial progress is advancing rapidly, led on by the increasing adoption of measurement and control.

◆ ◆ ◆ ◆ ◆

Attention Instrument Manufacturers

INSTRUMENTS invites descriptive announcements of your new products for publication in the New Instruments Section. But we hope that you will recognise this invitation also as a responsibility—the responsibility of presenting the descriptions of the equipment from the view-point of the user, not the seller.

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But when reading the New Instruments Section he reads as a user of instruments and control devices, interested only in its construction, its operation and what it will do. Please respect the interest and consider the requirements of the reader following the New Instrument Section. Provide us with a technical description of the apparatus explaining with diagrams its construction, presenting its principle of operation, and describing what it does and under what conditions it does that.

Admittedly it will call for more space, more time, and more work on our part to publish descriptive announcements in this way. But we feel certain that the thorough satisfaction of the reader more than justifies these greater exertions. In fact, should any manufacturer not care to take the trouble, our editorial staff will write the description. All INSTRUMENTS asks is that you provide the facts, the figures, the diagrams and illustrations—we'll do the rest.

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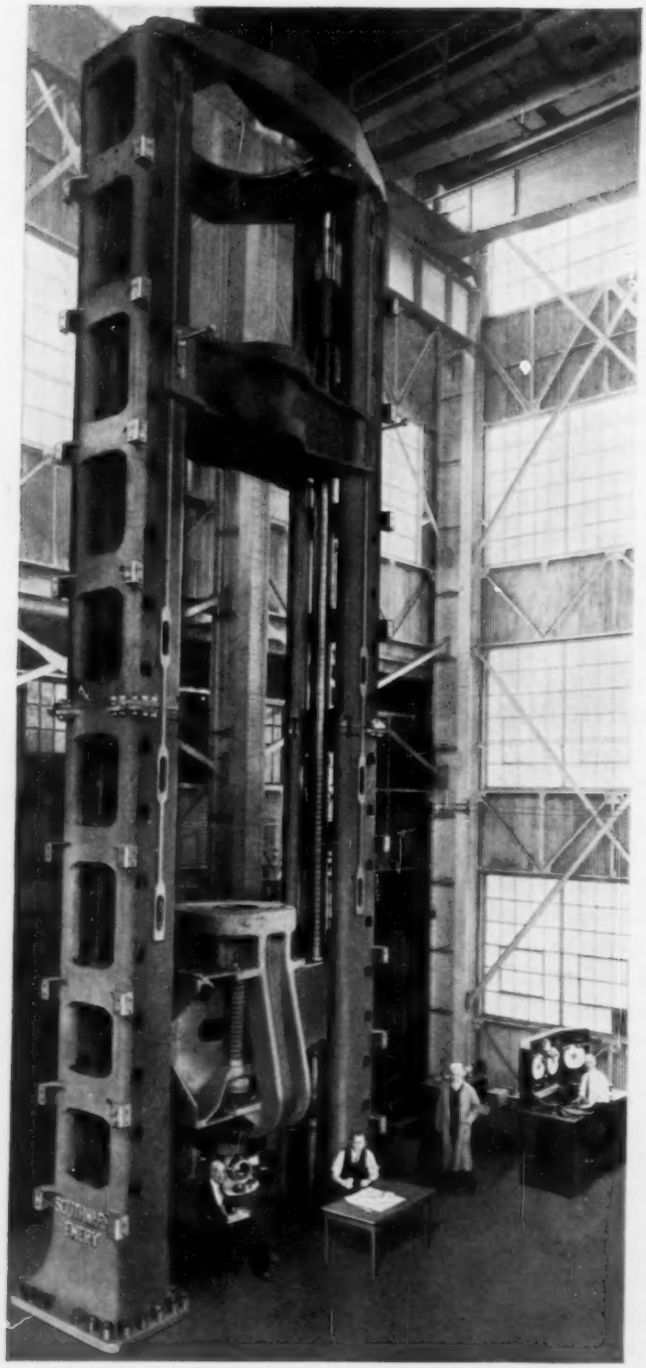

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Apparatus for Study of

DIESEL ENGINE COMBUSTION*

By A. M. ROTHROCK†

DURING the last five years the National Advisory Committee for Aeronautics has published considerable information on the formation of fuel sprays for high-speed compression-ignition engines. Some tests conducted by the N.A.C.A. indicated the necessity of extending the researches of the Committee to include a study of the spray formation and penetration into air at the temperatures and densities in the combustion chambers of high-speed compression-ignition engines.

As a result it was decided to extend the researches by constructing an apparatus that would permit photographs to be obtained of both the spray formation and combustion under conditions which closely simulate those in the combustion chamber of a compression-ignition engine.

This apparatus, designed and constructed at the Langley Memorial Aeronautical Laboratory, Langley Field, Va., consists of a single-cylinder test engine, a fuel-injection system so designed that a single charge of fuel can be injected into the combustion chamber of the engine, an electric driving motor, and a high-speed photographic apparatus.

Description of the Apparatus

Test Engine. The combustion chamber of the engine has a diameter of 3 in. and a depth of 7/8-in. This shape was chosen because it permits the two sides of the chamber to be made of glass disks. There are two 1-in. thick windows on each side of the chamber separated by an air space which is connected to a tank of compressed air. Since air temperatures of 2,000° to 3,000° F. and absolute pressures in excess of 800 lbs./in.^{2} are reached in the combustion chamber, the conditions to which the inner windows are exposed are extremely severe. By maintaining an air pressure between the windows of approximately 450 lbs./in.^{2} the stress is divided between the inner and outer windows. The combustion chamber is connected to the displacement volume of the engine by a rectangular orifice 0.695 in.^{2} in area to produce air flow in the chamber.

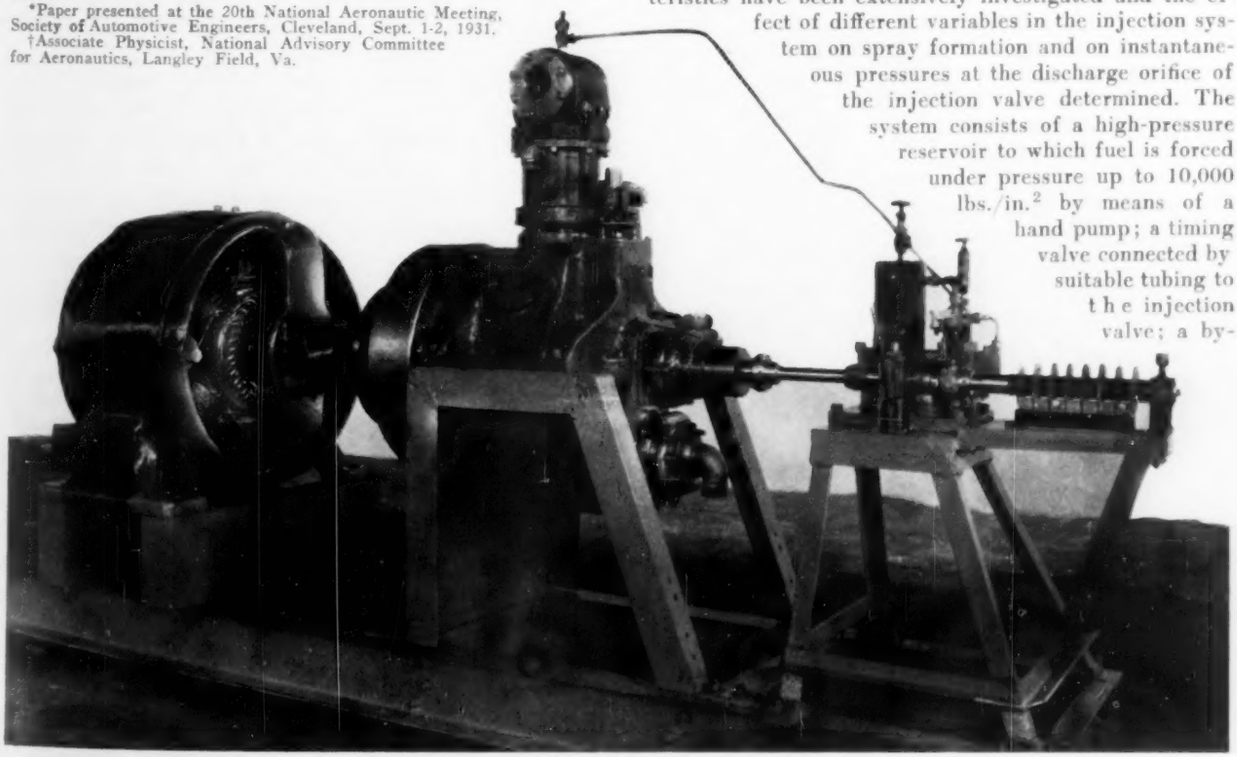
There are two openings in the cylinder head for the injection valve so that the effect of air velocities can be studied with the spray directed normal to and counter to the air flow. The third opening is used to attach a maximum pressure indicator.

The cylinder of the engine has a 5 in. bore and a 7 in. stroke. The compression ratio of the engine is 15.8:1. At the bottom of the stroke the piston uncovers ports in the cylinder wall. These ports are connected to a cam-operated poppet valve so adjusted that it opens when the piston is at bottom center. These ports and the valve permit air to enter the displacement volume and compensate for air leakage around the piston rings. In addition, the inlet manifold may be connected to an air compressor so that the effect of increased air density on the fuel spray and on the combustion may be studied.

Injection System. The injection system is the same type as that used on the N.A.C.A. spray photography equipment. This system was chosen because its characteristics have been extensively investigated and the effect of different variables in the injection system on spray formation and on instantaneous pressures at the discharge orifice of the injection valve determined. The system consists of a high-pressure reservoir to which fuel is forced under pressure up to 10,000 lbs./in.^{2} by means of a hand pump; a timing valve connected by suitable tubing to the injection valve; a by-

*Paper presented at the 20th National Aeronautic Meeting, Society of Automotive Engineers, Cleveland, Sept. 1-2, 1931.

†Associate Physicist, National Advisory Committee for Aeronautics, Langley Field, Va.



Test Engine Unit, Fuel-injection System, and Driving Motor.

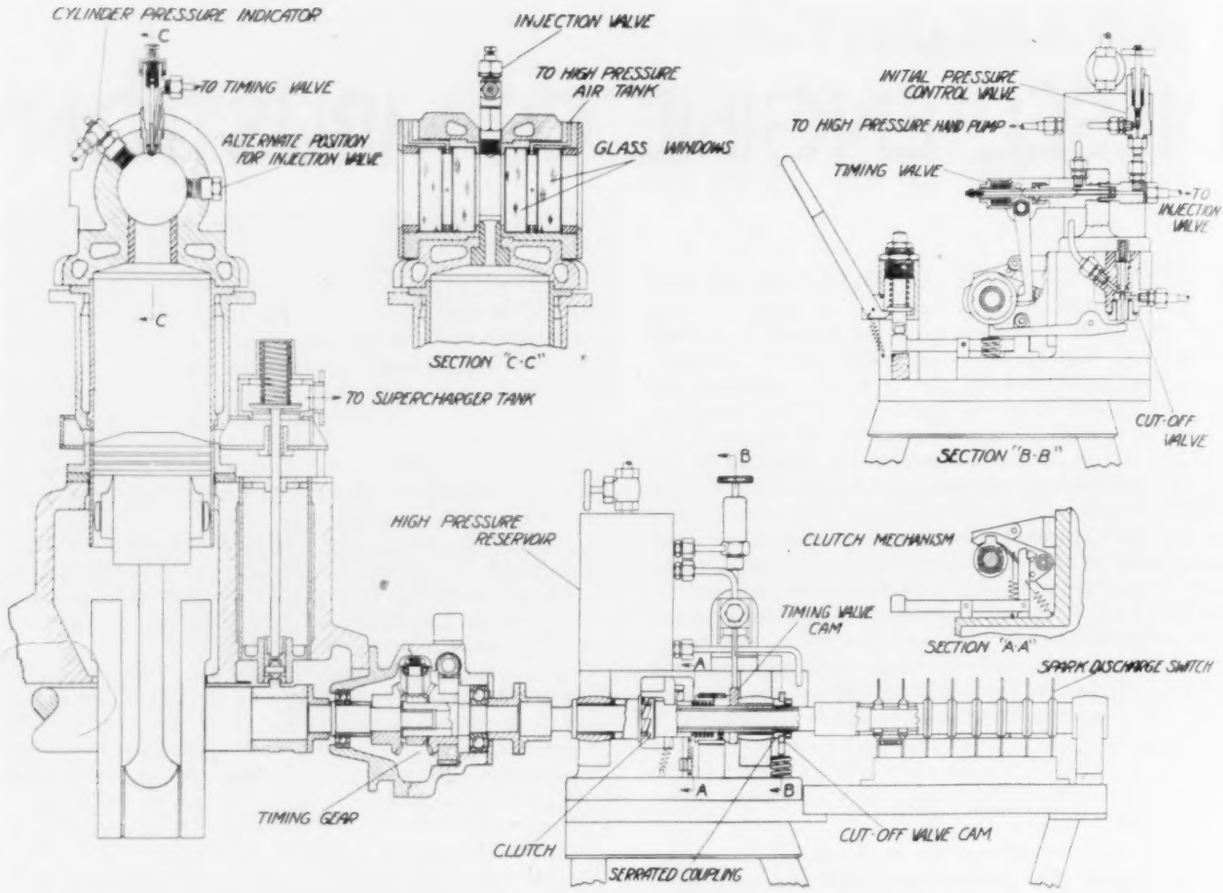


FIG. 2. DIAGRAMMATIC SKETCH OF TEST ENGINE UNIT

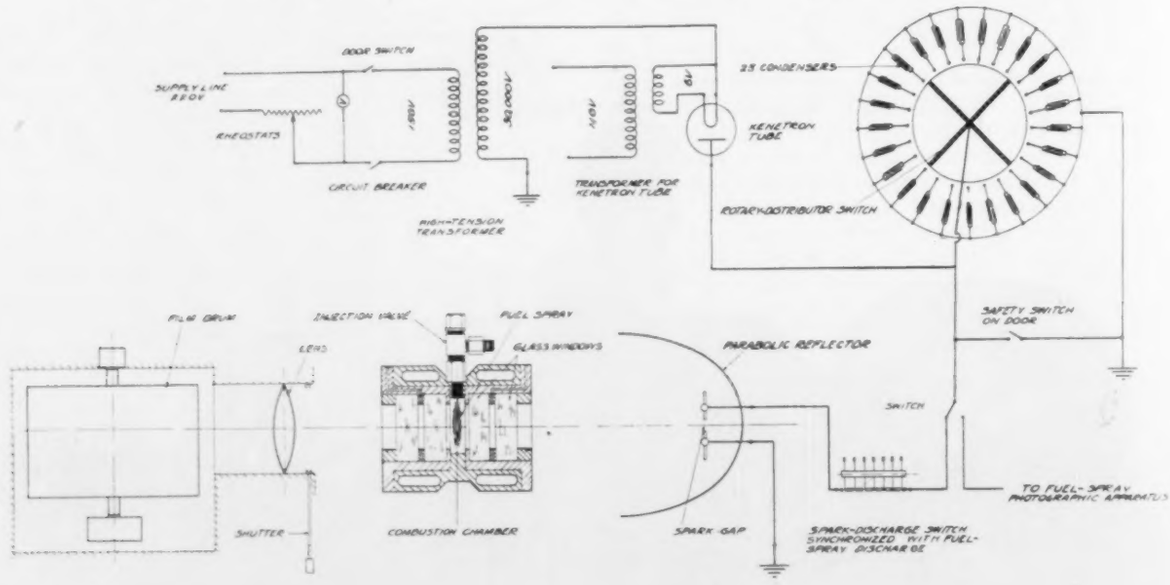


FIG. 3. PHOTOGRAPHIC APPARATUS

pass valve for controlling the injection period; and a valve for controlling the initial pressure in the injection tube before the start of injection. The tube connecting the timing valve and the injection valve is 50 in. long so that the instantaneous pressures at the discharge orifice will not fluctuate because of the pressure-wave phenomena. A hand-operated needle valve in the top of the high-pressure reservoir allows air to be exhausted from the reservoir.

One end of the crankshaft is connected to the electric driving motor, and the other end to the timing gear

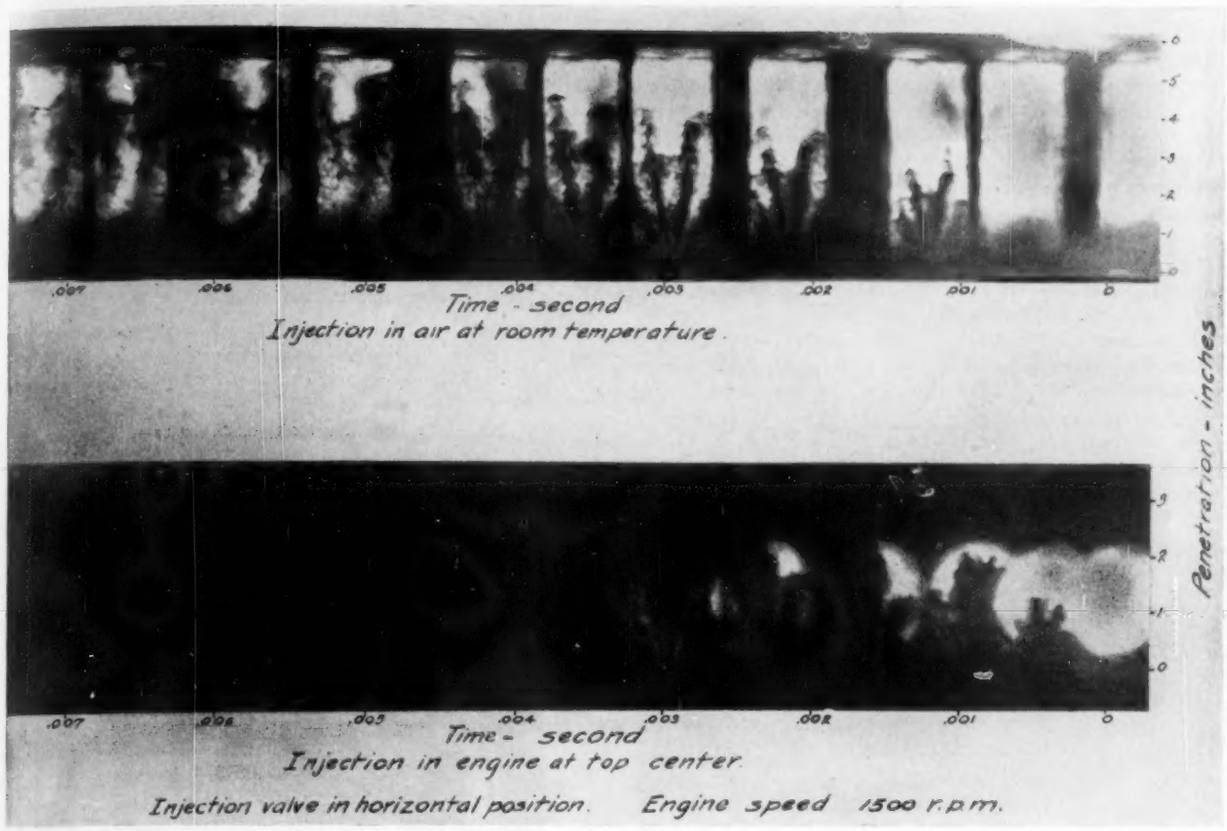


Fig. 4. In cold air, after cut-off of injection the spray diffused slowly throughout the chamber, but at all times light was diffused through the chamber. With injection into hot air, the spray diffused so completely as to block out the light after 0.004 second.

through which the injection system is driven. The timing gear is calibrated so that the start of injection can be varied in increments of one crankshaft degree. The shaft connecting the timing gear to the injection system is separated by a clutch similar to those employed on press punches. When this clutch is engaged by means of the mechanism shown in Fig. 2 the camshaft of the injection system makes a single revolution at a speed of one-half the engine crankshaft speed.

When the clutch mechanism is engaged by the operating lever the first cam opens the timing valve, which releases the fuel under pressure in the reservoir to the automatic-injection valve. Injection continues until the second cam opens the by-pass valve, at which time the hydraulic pressure in the high-pressure reservoir is released to atmospheric pressure and the injection is stopped. The period of injection can be varied by means of the serrated coupling connecting the by-pass valve cam to the camshaft.

Photographic Equipment. Fig. 3 shows a diagrammatic sketch of the high speed photographic system and the arrangement of the camera and the spark gap relative to the combustion chamber in which the injection valve is shown mounted in the vertical position. In the operation of the electric circuit the rotary distributor is driven at a speed of approximately 2,400 r.p.m. The primary circuit of the high-tension transformer is closed charging the electric condensers to 30,000 volts through the kene-

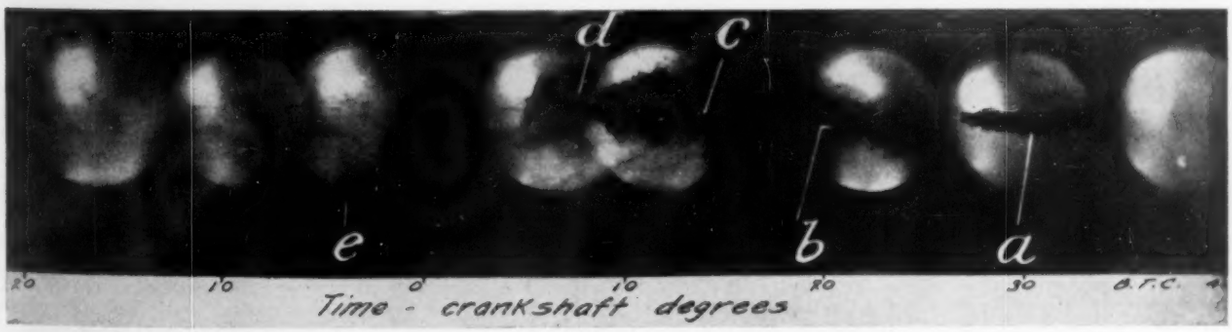


Fig. 5, shows the effect of air flow on the fuel spray from a single 0.020 inch orifice with the injection valve mounted in the vertical position. With injection starting at 40° before top center the spray penetrated across the section of the chamber included in the glass windows but was blown backward between 10° before top center and top center, after which cut-off occurred.

tron tube for rectifying the current. When the clutch for the fuel-injection system is engaged, the rotation of the camshaft closes the spark-discharge switch grounding the condensers through the spark gap. The condensers are therefore consecutively discharged as the contacts on the rotary distributor complete the condenser circuits. With the four contacts as shown in Fig. 3 the rate of discharge of the condensers is 4,000 per second. For the present series of tests two of the contacts were removed giving a rate of discharge of 2,000 per second. The light from each condenser discharge is focused by means of the parabolic reflector onto the combustion chamber. The lens mounted in the camera then focuses the image of the chamber onto the film mounted on the rotating film drum. The drum has a diameter of 30 ins. and turns at a peripheral speed of 2,000 ins./sec. By means of a serrated coupling connecting the spark discharge switch with the camshaft, the time of start of the spark discharges can be synchronized with the start of the fuel injection into the combustion chamber. When the injection takes place the light from the spark discharges is intercepted by the fuel spray so that silhouettes of the spray are recorded on the photographic film. When combustion takes place the light of the combustion is focused onto the rotating film by the lens. Consequently, high-speed motion pictures are obtained of the spray but a continuous picture is obtained of the combustion. Standard commercial photographic film is used with satisfactory results.

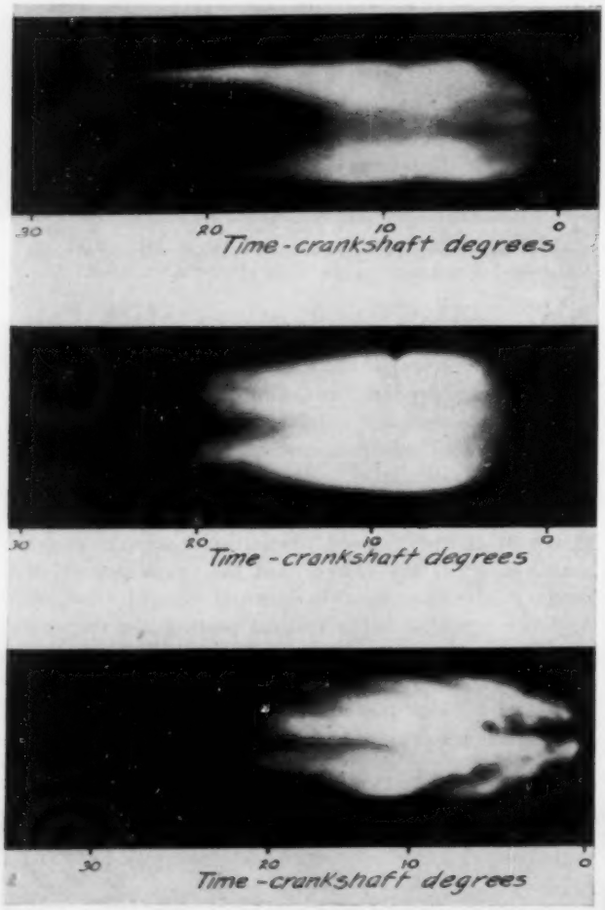


Fig. 6. Three photographs of combustion under these conditions (cylinder-head and jacket heated to 190°—200° F., fuel ratio 5:1) are shown. The top photograph shows rather weak combustion starting almost simultaneously throughout the combustion chamber. The end of combustion occurred in the center of the chamber before the burning died out along the edges of the chamber. The middle photograph shows strong combustion starting almost simultaneously throughout the chamber and dying out in the center of the chamber and then along the edges of the chamber. The bottom photograph is particularly interesting because it shows combustion starting in different parts of the chamber, finally filling the whole chamber; and then dying out on one edge before the stop of combustion in the center and outer edge.

Tests and Results

Some tests were made to determine the effect of air temperature and air flow on the spray formation. All tests were conducted with a Diesel fuel having a viscosity of 35 Saybolt seconds universal and a specific gravity of 0.83 at 100° F. The results show that temperature has little effect on the penetration of the fuel spray but does affect the dispersion; and that air velocities of about 300 ft./sec. are necessary to destroy the core of the spray.

The results on the combustion of the spray show that when ignition does not take place until after spray cut-off the ignition may start simultaneously throughout the combustion chamber or at different points throughout the chamber. When ignition takes place before spray cut-off the combustion starts around the edge of the spray and then spreads throughout the chamber.

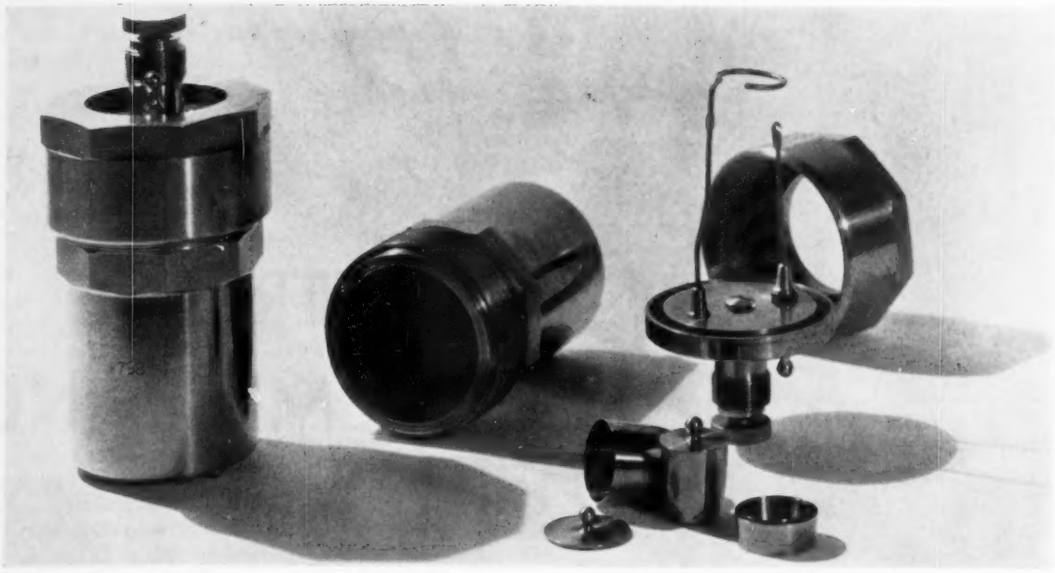
◆ ◆ ◆ ◆ ◆

William L. Patterson, director of the Technical Bureau of the Bausch & Lomb Optical Company, Rochester, N. Y., died suddenly in the company's offices while at his work on Friday morning, February 5. Mr. Patterson had been connected with Bausch & Lomb for a period of 38 years, having joined the organization in December 1894. He was born July 24, 1873, in Wilmington, Delaware.

The achievements of Mr. Patterson in the designing of microscopes and projection apparatus place him in the forefront of this field of scientific endeavor. There is no question but that the world has lost a great designer of these optical instruments in his death.

The soundness of his designs is shown by the fact that many of the early projection outfits that he perfected have stood the test of time, being still sold in their original shape. Nearly 50 United States patents have been issued to Mr. Patterson during these years, and many of these patents have been for features which added noteworthy contributions to the advancement of science through optical methods.

Mr. Patterson's first work for Bausch & Lomb was in the sales office and he was for a time in the New York City office. Later he coöperated with Edward Bausch, the present head of the company, in designing microscopes and other instruments during that period when optical products were in the pioneering stage of development. In time the Technical Bureau was formed and Mr. Patterson placed in charge as director of its activities, a position which he held at the time of his death.



A New Metal For Instruments

By W. D. STALEY*

ILLIUM is an alloy composed principally of nickel, chromium, copper, molybdenum and tungsten, with smaller amounts of iron, manganese, silicon and carbon. Although iron is present, there is so little of it that Illium is classified as a non-ferrous alloy.

It is strong, dense, hard without being extremely brittle, readily machined and polished, readily welded to itself or other metals. It withstands the action of all the common corrosive reagents at all ordinary temperatures, except wet chlorine or hydrochloric acid in strength exceeding 5%.

Illium has found its greatest use to date in places where severe corrosive conditions are encountered, such as filter parts, agitators, nozzles, etc. It is an ideal material, however, for many instrument parts.

In the field of measurement and control, calorimeter bombs made of Illium are well known—a severe test, considering the enormous pressures produced, plus combination of sulphuric and nitric acids generated by the combustion. Illium crucibles, thermocouple tubes, thermometer wells, pyrometer tubes and instrument housings are also coming into use. Here again the metal is at a decided advantage because of its ability to withstand not only single corrosives, but mixtures such as nitric and sulphuric acids. Its density protects again leakage under pressures of 1000 lbs./in.^{2} and more, while its satisfactory machinability makes for economy in manufacturing costs. The fact that it takes a high polish makes it suitable for external parts and casings, as it adds to the appearance of the device.

Listed below are some of the physical characteristics of Illium:

Tensile strength	50,000 lbs./in.^{2}
Elastic Limit	50,000 lbs./in.^{2}
Hardness—Brinell	170—200
Hardness—Rockwell "B"	87—93
Melting Point	1300° C. (2372° F.)
Specific Gravity	8.3
Weight per cubic inch	0.3 lb.
Coefficient of expansion per °C. (Range 20°—300° C.)	0.0000135
Electrical Resistance	121.9 microhms/cm.^{3}
Contraction in casting	$\frac{3}{16}$ in./ft.
Machinability	Slightly harder than cast steel.

*General Manager, Burgess-Parr Company, Moline, Illinois.

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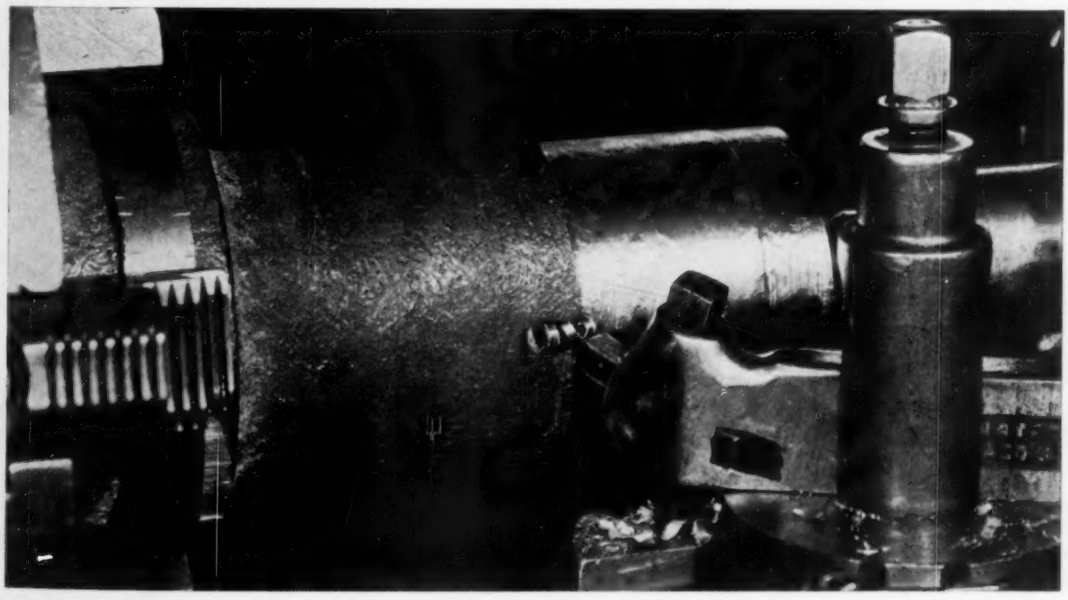
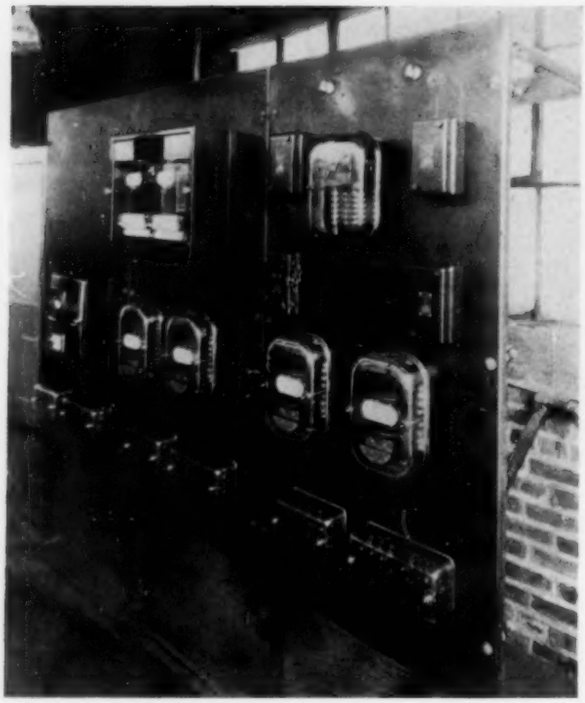




An installation of the Westinghouse current-impulse telemetering system.

ELECTRICAL TELEMETERING

By H. OLKEN*

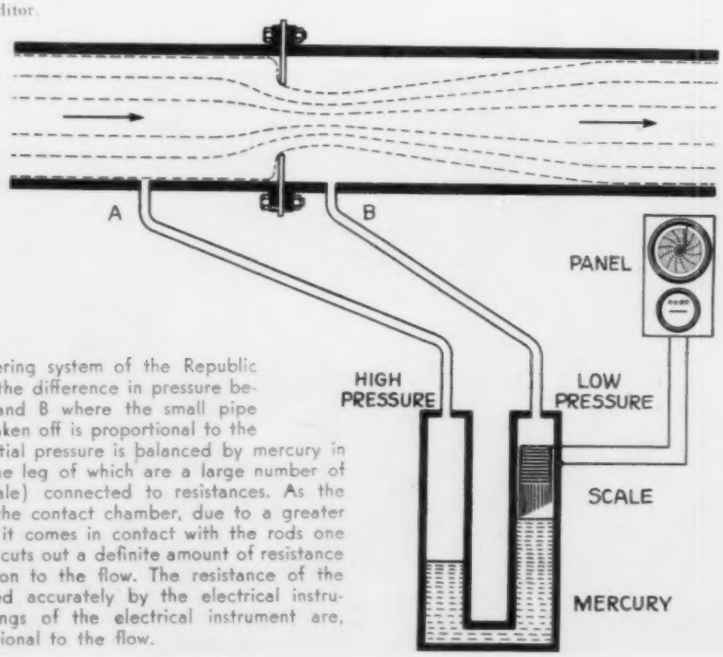
RECEIVING a meter indication at a distance from its originating point has in recent years become a basic control practice in industry. Telemetering is the new name for this art of remote metering, but the art itself is not of especially recent creation. Many principal elements of remote metering were worked out in the development of supervisory equipment for electrical power networks, electrical clock systems, automatic telephone exchanges, and distant tuning controls for radio sets. As a result there are available a bewildering number and variety of telemetering methods and systems. But in spite of this super-abundance of material underlying the subject, the present state of the telemetering art can be realised clearly from a brief outline of the different systems upon the basis of their operating principles.

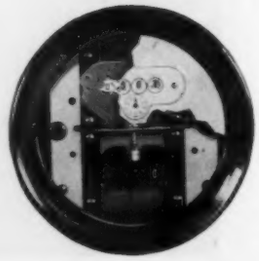
*Engineering Editor.

Actually there are but four basic principles whereby a desired indication can be transmitted to a distant point. These are: variation of electrical quantities in a circuit joining receiver and transmitter, the null or balance principle, the principle of synchronisation, and the selection principle.

VARYING TIE-CIRCUIT

Simplest of these is the principle of varying electrical quantities in a circuit at the transmitter, and reading the change at the receiver end of the circuit. This is the principle underlying the Hartmann und Braun system[1] and one system of Siemens & Halske.[1] In the Siemens & Halske arrangement, a change in position of a rheostat contactor at the sending point changes the reading on a meter at the receiving point. The contact arm may be actuated by the float of a liquid level indicator. In that





In the telemetering system of the Republic Flow Meters Co. the difference in pressure between points A and B where the small pipe connections are taken off is proportional to the flow. This differential pressure is balanced by mercury in a "U" tube in one leg of which are a large number of contact rods (scale) connected to resistances. As the mercury rises in the contact chamber, due to a greater flow in the pipe, it comes in contact with the rods one after another and cuts out a definite amount of resistance in direct proportion to the flow. The resistance of the circuit is measured accurately by the electrical instruments. The readings of the electrical instrument are, therefore, proportional to the flow.

case the distant meter, calibrated in feet of liquid depth, would indicate the liquid level even though it be miles away from the float.

A more modern version of this principle[2] employs a meter whose pointer carries a light-weight, opaque card. When this card is moved by the pointer it blocks out more or less of a light beam passing to a photocell. The photocell current changes with the amount of light admitted to it. A meter at a distant point, reading the photocell current, therefore indicates the position of the pointer card at the transmitter.

Suppose the transmitting meter responds to a thermocouple voltage indicating the temperature of a furnace. Then the transmitter is a millivoltmeter; but even a millivoltmeter can carry a light-screening card, so its readings could be transmitted to a distance by this photoelectric method.

Simplicity is the outstanding feature in systems using this principle of changing an electrical quantity at one point in a circuit and reading the change at a point even miles distant. Along with this simplicity goes low cost of apparatus and easy maintenance.

Refinements and elaborations of the simple principle can be made. For instance, by using a differential-meter adaptation, Siemens & Halske derive a system independent of fluctuations in transmission power supply voltage or changes in line resistance.[1]

Republic Flow Meters Co., for example, uses as transmitter a variable resistance changing with the mercury level in a manometer. As receiver, a meter working on the wattmeter principle measures the circuit resistance, thereby indicating the mercury level in the manometer. This arrangement provides a highly trouble-proof transmitter and freedom from power supply voltage fluctuations.

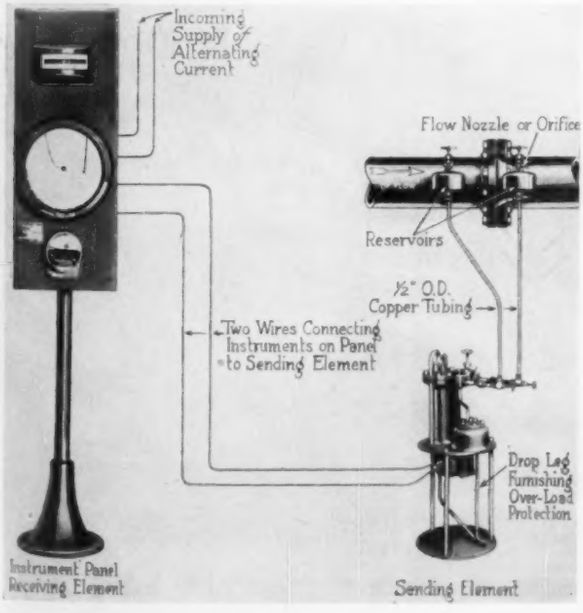
The Bailey Meter Company's modification of this principle takes advantage of the change in equivalent resistance of a transformer secondary when the manometer column of mercury serving as transformer core changes in height. A meter on the wattmeter principle, measuring the circuit admittance, indicates at the receiving end of the circuit the changing heights of the mercury column. An advantage realised here is the variation of circuit resistance without making or breaking contacts.

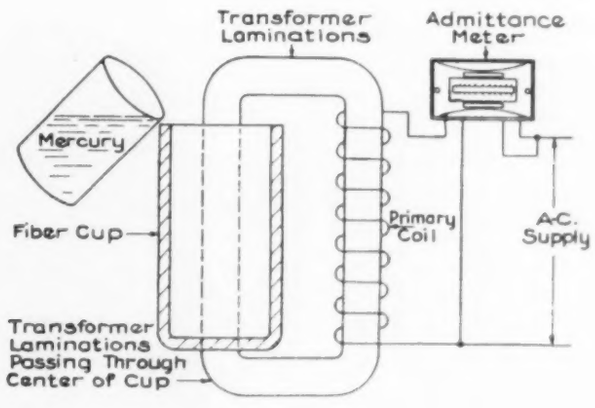
Both the Republic and the Bailey systems, using indicators operating on the wattmeter principle, have this advantage for flow applications; by simply using a watt-hour-meter instead of a wattmeter, flows can be integrated to give total quantity of gas or steam transferred by the flow.

These refinements provide added features, but they may increase the initial cost of equipment and often also the maintenance requirements. To illustrate—the photocell transmitter above mentioned presents the feature of *not* putting a burden on the element whose indications are to be transmitted—a very desirable feature for meters working on such inputs as a milli-voltmeter. But the photo-cell adds complication to the apparatus and increases its cost with the need for amplifiers to amplify its faint current enough to make distant transmission practical.

A further illustration of the added features that can be obtained in telemetering by this simple principle, though at the expense of increased complication and cost of apparatus, is the frequency variation method.[5] The transmitter actuating element moves a condenser plate, thereby changing the frequency of an oscillator of which the condenser is the frequency-controlling element. A frequency-indicating arrangement at the receiver end of the line responds to these changes, in this way reproducing at a distance the changes in position of the transmitter. Suppose the actuating transmitter element is a vane on the rotor of a watt-meter, at a substation. Then by having a frequency indicator at the central station, an operator can read the substation load.

Outstanding features are afforded by this frequency system. Existing power or telephone lines can be used as the telemetering transmission lines, in addition to their power or phone transmission, thus saving the cost of a special telemetering channel. This is possible because the range of telemetering frequencies used can be far above the power or communication frequencies, hence avoiding the possibility of interfering with, or being interfered with, by these frequencies. Furthermore, variations of line conditions (resistance, capacity, etc.) do not disturb


Incoming Supply of Alternating Current
Flow Nozzle or Orifice
Reservoirs
½" O.D. Copper Tubing
Two Wires Connecting Instruments on Panel to Sending Element
Drop Leg Furnishing Over-Load Protection
Instrument Panel Receiving Element
Sending Element



Variation in mercury level by a flow manometer changes the resistance of the telemetering circuit in the Bailey transformer system, and the change is indicated by an admittance meter at the receiver.

the accuracy of telemetering, because they do not affect the telemetering frequency.

Eliminating cost of connecting lines and securing freedom from line variations are both valuable features, but to obtain them calls for a variable oscillator, which complicates the apparatus considerably, and a frequency indicating apparatus, which appreciably increases the cost of equipment. All this is brought out to illustrate that telemetering systems based on even the simplest principle of changing a circuit at one point, and reading the change at a distant point in the circuit, have already been developed so a variety of features and many refinements are to be had.

NULL OR BALANCE TYPES

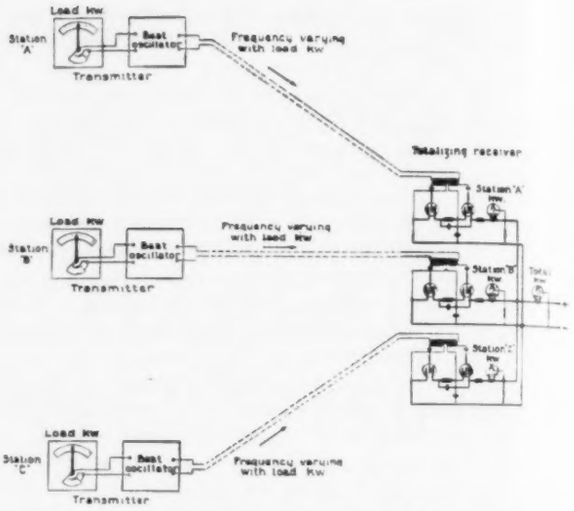
On the null or balance principle there are several types possible. Receiver indications can be made equal to the transmitter readings by balancing a mechanical element, by potentiometric balancing of voltages, by bridge balancing, or by balancing induction torques.

Current Balance

Balancing of a mechanical element is used in the "current balance" systems. The Westinghouse Electric & Manufacturing Co. produces one system of this type, in which a motor is rotated in one direction or another, changing a resistance to increase or decrease the current in the receiver meter. When the receiver current is equal to the current through the transmitter meter, a Kelvin current balance comes to a balanced, neutral, position and stops the motor, leaving the transmitter and receiver meter both indicating the same current. Lately they have supplanted the motor and variable rheostat by a vacuum tube arrangement, the function of which is explained in the diagram.

Any number of receivers can be tied on to one transmitter by putting the desired number of receiving ammeters in series. This asset is, however, in one respect a liability, because if the wire joining all the receivers should break, they all go dead at once. A feature inherent in this system is that the distance of transmission can be very great, because an auxiliary power source is used to actuate the receivers.

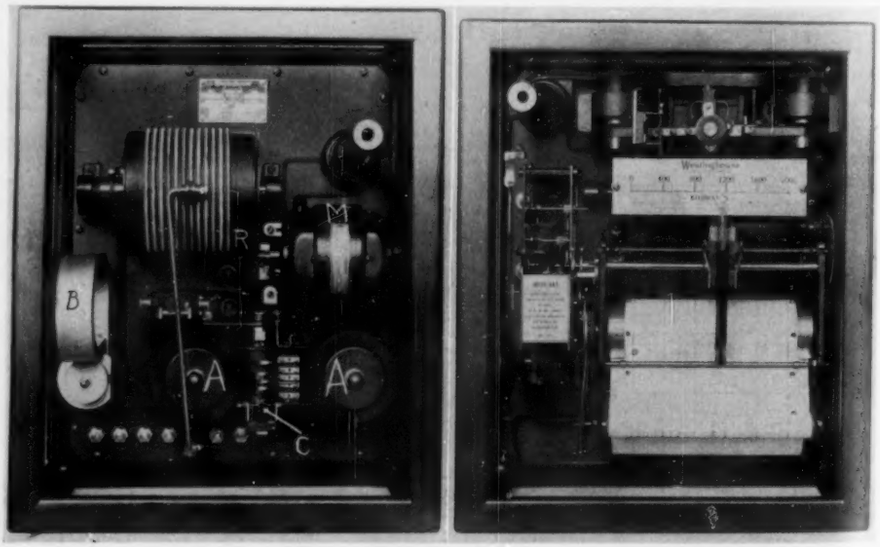
An interesting advance in telemetering by a current-balanced mechanical element was recently made with the development of the General Electric Company's photo-electrically operated "torque balance" system.



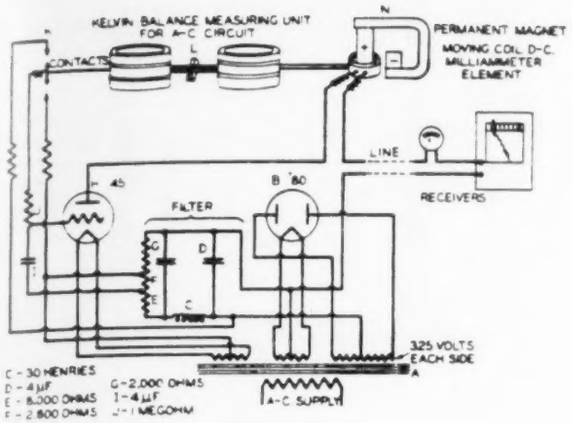
A small section air condenser is attached to the meter movement and the condenser position determines the frequency of an oscillator. This relatively low frequency creates beats with a high frequency of fixed value from a supplementary oscillator and the beat frequency actuates the indicating device at the remote point.

The indication to be transmitted is converted into a torque magnitude applied to a rotating mirror (see diagram). When the operating element produces an indication the mirror turns, focussing more light on one of the photoelectric tubes and less on the other, thus increasing the current output of one photocell and decreasing that of the other. The current difference between photocell outputs, amplified by a vacuum tube, flows through the restraining element, balancing the torque generated by the operating element. The resultant unbalance current indicates, on the instrument in the load supervisor's office, the torque on the operating element, which is in turn an indication of the quantity being metered.

Since the torque of the two elements is continually being automatically balanced, variations in supply voltage, line resistance, tube emission, or light-source brightness are to a large extent automatically compensated for.



In the transmitting voltmeter of the Westinghouse current-balance system the coils A-A constitute a Kelvin balance type element which develops torque on the meter element proportional to the square of the applied voltage. B is a permanent magnet, and with its associated pole pieces and moving coil forms a d'Arsonval type direct-current element for measuring the transmitted direct-current. Its torque is proportional to the current transmitted and opposes the torque of the a. c. voltmeter element A-A. This is the normal condition of the measuring element. If either part of the element has higher torque than the other, the measuring element turns, closing one or the other of the contacts C, which results in the motor M adjusting the rheostat R, so that the current in element B is corrected to balance the torque of the voltage applied to A-A. The current transmitted is proportional to the square of the voltage and a direct-current meter may have its dial graduated in volts and placed in the circuit wherever convenient.



Power, voltage, current, or whatever entity is to be remotely indicated is applied in the Westinghouse vacuum-tube current-balance system to the measuring element L and produces a torque tending to close one of the contacts K. An electro-magnetic counter-torque is established by the d-c. element N, which carries the telemeter current in the communication line, this of course being the current measured by the remote receiving meters. These two torques are applied against each other by the composite a. c.-d. c. balance mechanism L-N. If they do not balance exactly, contacts K operate to adjust the direct current (which is supplied from the plate circuit of tube H) to the balancing value. When the upper contacts close, the grid voltage of tube H is increased and the plate circuit is correspondingly reduced; when the lower contacts close, the grid voltage is reduced thereby increasing the plate current. The resistance J slows down the charging time of the condenser I enough to allow the balance L-N to open the contacts and stop charging when the proper current value is reached.

Potentiometric Balance.

A "thermal converter," or device which generates a milli-voltage in proportion to the power in an a. c. line, is used by Leeds and Northrup as the transmitter in a system for telemetering power. The receiver is a recording potentiometer which automatically balances the milli-voltage from the transmitter with an equal and opposite voltage at the receiving point.

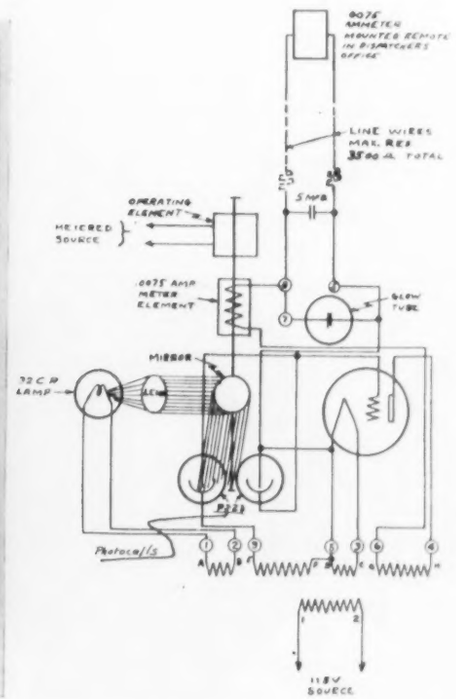
The simplicity of the transmitter and low cost of the entire equipment are the advantages afforded by this system. However, its application is limited to local transmission, because the minute voltage used leaves no margin of dependability against stray voltages or poor line conditions. Yet if vacuum-tube amplified voltages be used over the transmission line, this system may present considerable possibilities.

Bridge Balance.

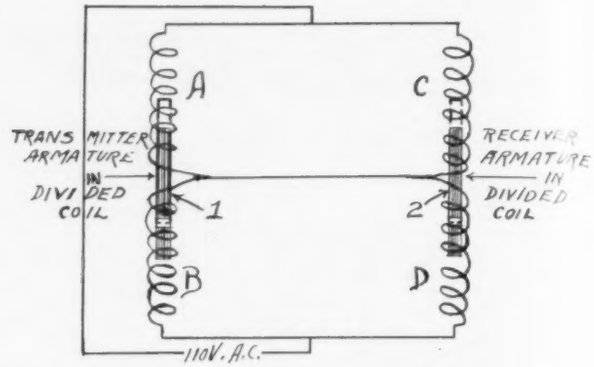
The self-balancing inductance bridge is the basic principle in both the Brown Instrument Co. and the Bristol Co. telemetering systems. Such a circuit, reduced to its elements, is diagramed in the illustration.

Suppose at the outset that both armatures, Nos. 1 and 2, are in a central position between the respective pairs of coils. A state of electrical equilibrium prevails in the circuit, and no current will flow through 0.

Now suppose a change in the pressure, or other factor transmitted, acting on the transmitter, causes the transmitter armature (No. 1) to be moved farther into coil A and out of coil B. This causes the inductance in coil A to increase, while the inductance in coil B correspondingly decreases. Consequently current flows through 0, increasing the current in C. The current in coil C, ex-



When the operating element of the General Electric torque-balance system produces an indication the mirror turns, focusing more light on one of the photoelectric tubes and less on the other, thus increasing the current output on one photocell and decreasing that of the other. The difference between the photocell outputs flows through the restraining element, balancing the torque generated by the operating element. The resultant unbalanced output indicates, on the instrument in the load supervisor's office, the torque on the operating element, which is in turn an indication of the quantity being metered.



The self-balancing inductance bridge is the basic principle upon which Brown Remote Type Instruments operate. The above diagram illustrates such a circuit reduced to its essential elements and connected to a suitable source of alternating electric current.

ceeding that in coil D, causes the receiver armature (No. 2) to move out of D into C. Movement of armature No. 2 into C causes the inductance in the latter to increase until electrical equilibrium is again established in the circuit, current no longer passes through 0, and the electric currents in A, B, C, and D are once more equal. This condition continues until core No. 1 is again moved, whereupon core No. 2 again follows the motion, the receiver pointer or pen arm indicating or recording the new position.

The Bristol system is electrically identical with the Brown, but differs mechanically in that the cores are fixed and the coils move.

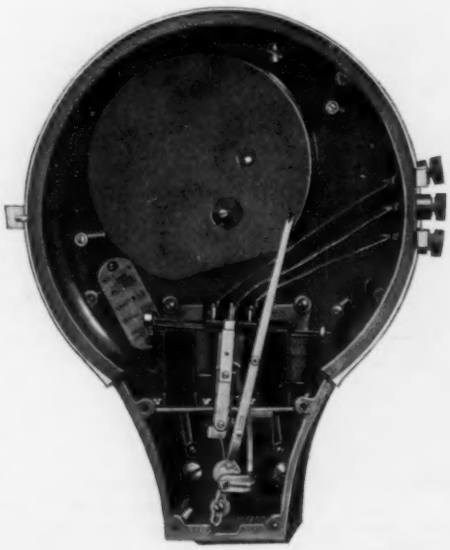
Induction Torque Balance.

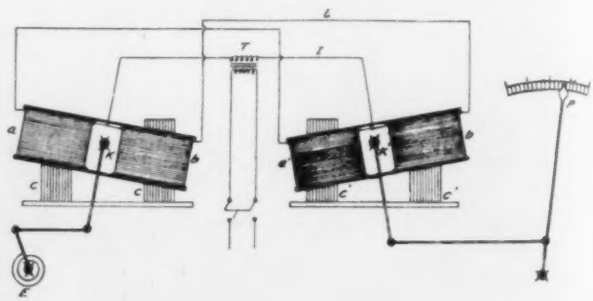
One method based on this principle featuring the advantage of simple apparatus for both transmitter and receiver is that of Trüb, Täuber & Co., Switzerland.[4]

Referring to the diagram, the left-hand movement, which we shall call the transmitter, has its moving coil 5 mechanically coupled to some originating movement. The moving coil is connected, by means of lead wires, in series with the moving coil 6 of the repeating instrument. The field systems 2 and 4 of the transmitter and repeater respectively are connected to a common source of supply. Assuming that the moving coil of the transmitter is in a given position, the flux due to the field coil induces in the moving coil an e. m. f. which is proportional to the angle between the plane of the moving coil and the resultant field flux. The e. m. f. thus induced in the moving coil circuit causes a current to flow in the moving coil circuit. This current, together with the field flux of the repeater, produces a torque causing the moving coil 6 to deflect until the e. m. f. induced in this coil exactly counterbalances the e. m. f. induced in the moving coil of the transmitter. As soon as this condition is reached, current ceases to flow in the moving coil circuit, and the moving coil of the repeater comes to rest. Assuming that the field strength of the transmitter and repeater is exactly the same, the position taken up by the repeater moving coil will be exactly similar to the position of the transmitter.

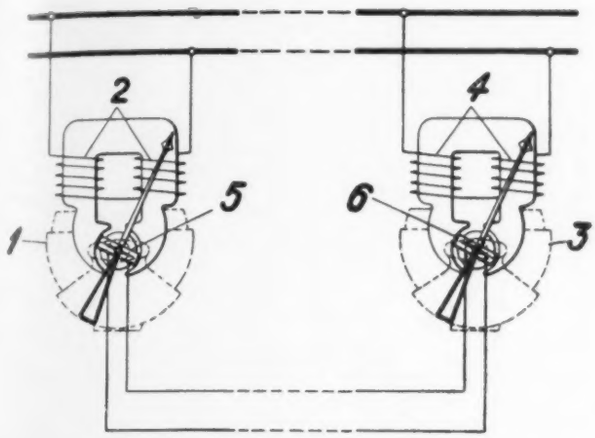
As the system is based on the compensation of two e. m. f.'s, it will be readily understood that the reading of the repeater is independent of the resistance of the lead wires or contact resistance of switches which may be connected in the circuit. In practice, however, the resistance of the lead wires is limited by the torque necessary to operate the repeating instrument; thus, for ordinary indicating repeaters, the lead wires may have a resistance up to 7,000 ohms and for recording repeaters up to 500 ohms. A single transmitter can be arranged to operate a large number of repeaters, the latter being connected in parallel.

An important feature of this system of remote measurement lies in its application to summation of the readings of a number of instruments calibrated in the same unit. The principle of the system as applied to summation does not differ from that already described, but the individual transmitter movements are connected in series. The repeater thus indicates the net sum of the readings of the individual transmitters.

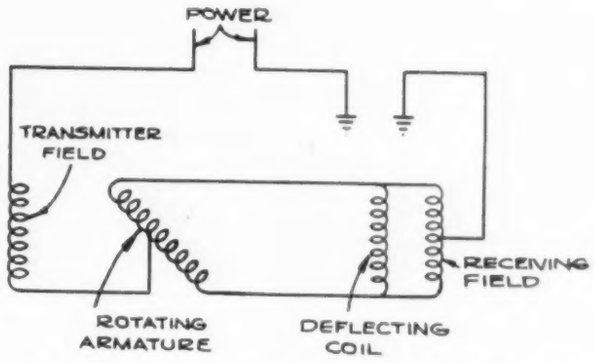




In the Bristol Company's self-balancing inductance-bridge system each instrument has 2 coils that are mechanically balanced, supported on knife edges, and swing in a vertical plane over laminated iron cores. The position of the transmitter coils is determined by the pressure, temperature or mechanical element that actuates same, while the position of the receiver coils is determined electrically by the position of the transmitter coils.



Trüb, Täuber and Company's induction torque balance system, in which both sending and receiving instruments are identical. The field coils, 2 and 4, fed from the power line, provide the driving force. Indicator coils 5 and 6 come to rest when in corresponding angular positions with respect to the field coils.



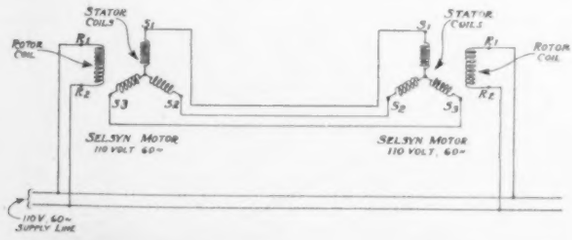
Both sending and receiving instruments of the Wallace & Tierman Co. system have a field coil which furnishes an operating flux. An armature coil is rotated in this flux, which transmits a secondary current to the deflecting coil of the receiving instrument. In this deflecting coil is created a north and south pole of strength proportional to the amount of flux cut by the armature. The greater the angle the armature is turned, the stronger is the pole created in the deflecting coil and the further is the needle pulled to one side.

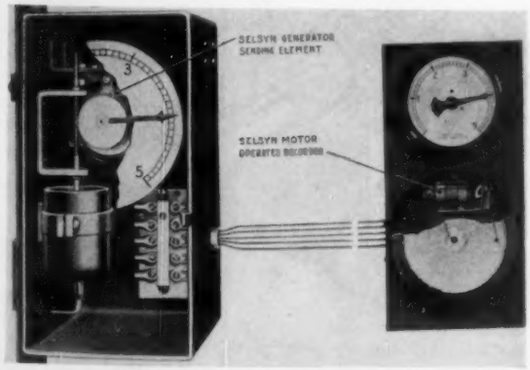
An American modification of this system is that of Wallace & Tiernan Products, Inc. The transmitter is the same, a coil whose induced e. m. f., hence the current through it, varies with its position relative to an a. c. field; but in the receiver the current from this transmitter coil magnetizes a stationary magnet, and an iron vane armature is rotated by the magnet in proportion to the transmitter-coil current.

Limiting the transmitter coil's angle of movement eliminates need of slip rings, making the receiver coil stationary; and using the magnet, instead of springs, for centering the receiver armature helps to make the system mechanically dependable.

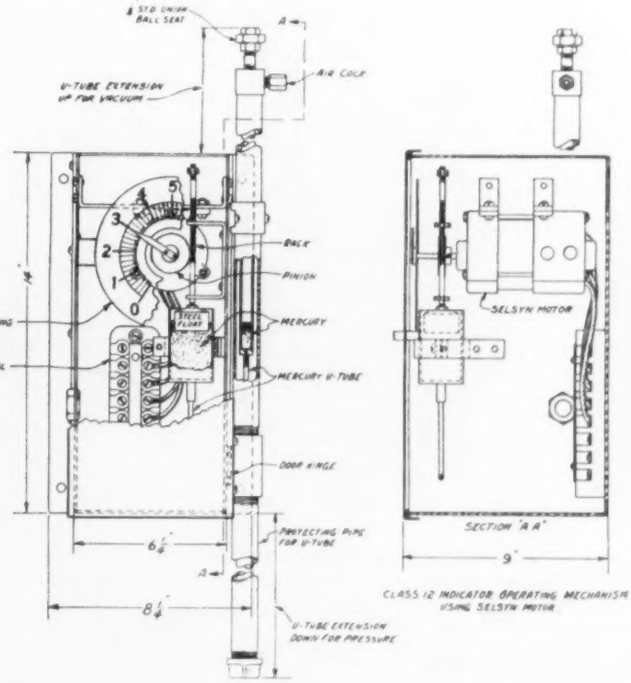
Also working on the principle of balancing torques due to induced e. m. f.'s is the Selsyn or DeFlorez system. Here two identical 3-phase induction motor stators are tied to the same line, one at the transmitter end, the other at the receiving point. The rotor in each induction motor is single phase, and both rotors are connected together and fed by a two-wire transmission line. With both rotors left at rest, each stator has induced in it e. m. f.'s equal and opposite to the e. m. f.'s received from the other, so there is no current in either stator and neither rotor is turned by a rotating magnetic field in its stator. If we call one rotor the transmitter and have it turned by an operator, the balance of induced e. m. f.'s in both stators is disturbed. The resulting unbalance current in the line joining the stators will be such as to cause the other rotor, or receiver, to rotate. When the receiver has been rotated through the same angle as the transmitter, the stator e. m. f.'s will again balance, and the receiver will come to rest at the same position as the transmitter.

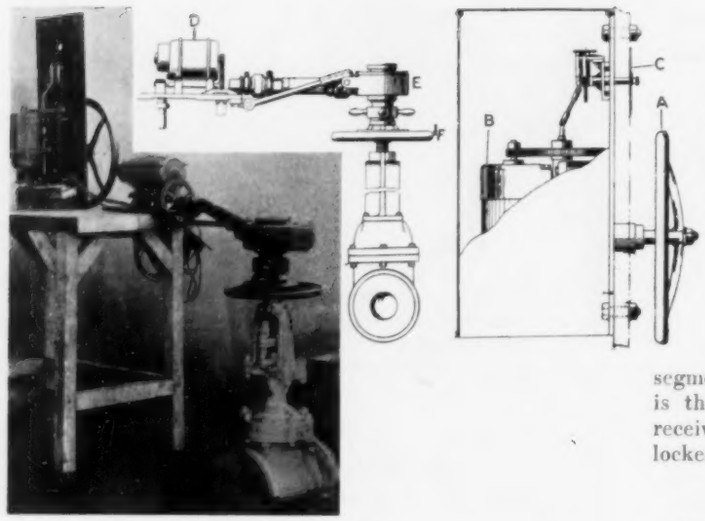
This system is burdened by the need of a 5-wire line —a 3-phase stator line, and a 2-wire line to connect the rotors, but it affords some unique advantages. One is that either motor may be used interchangeably as both a transmitter or receiver, making possible two-way trans-





Bailey Meter Company's Selsyn system for mercury U-tube type pressure and liquid-level transmitters.





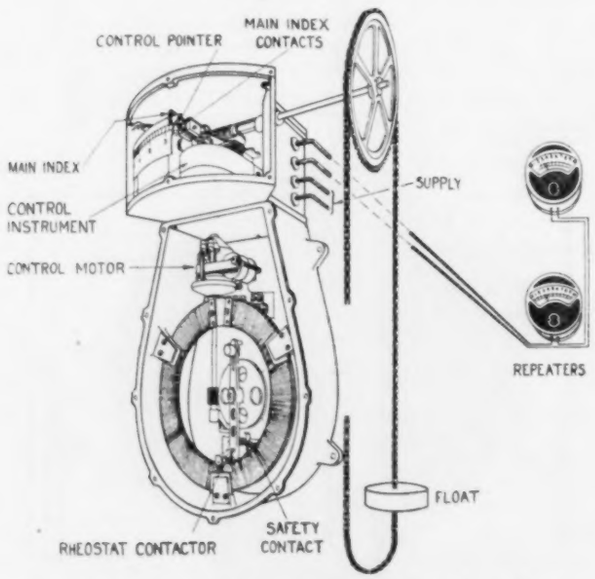
The Brown Selsyn system works thus: 1. Turn the wheel (A). 2. Wheel motion moves armature of transmitting motor (B); also moving indicator hand (C). 3. At remote control point receiving motor (D) armature turns synchronously with armature of transmitting motor. 4. Receiving motor armature, operating through suitable linkage and gears (E), operates valve (F) or other mechanism to be controlled. 5. Dial of indicator (C) at transmitter moves in synchroism with motor (D), showing operator position of distant control setting.

mission of indications over the same line. Another and greater feature is that the same torque is produced by the receiver motor as was applied to transmitter rotor. Where it is desired to convert the received indication directly into a control function, one need only couple the control apparatus to the receiver shaft. Thus for example, if a valve in a steam line is coupled to a Selsyn receiver shaft, it can be turned by a power-house operator a great distance away. Due to the interchangeable two-way transmission feature in this system, the operator gets the "feel" of the valve—that is, the harder it is to turn the valve, the harder it is for him to turn the transmitting rotor.

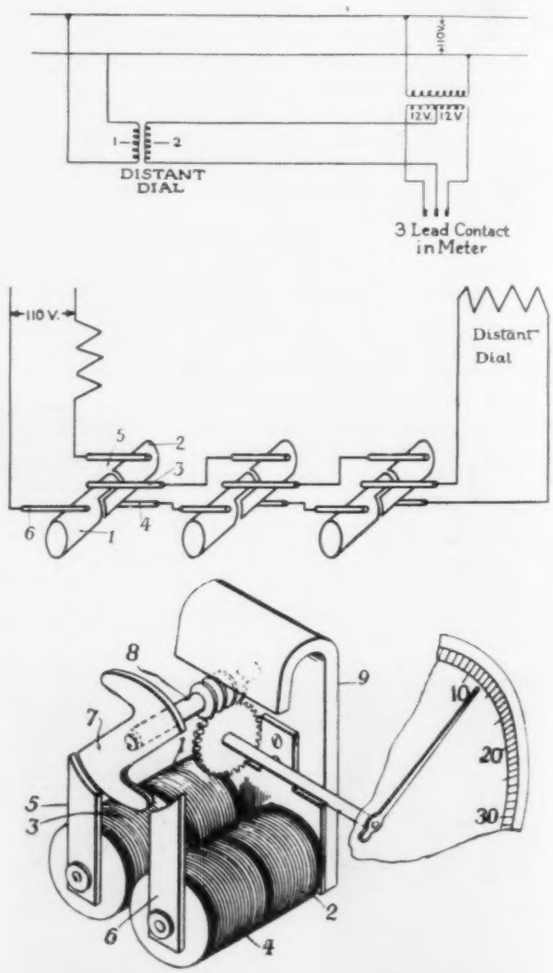
A refinement of the Selsyn system was developed in a remote-tuning device for radio sets. The system, called the "National Kinematic Remote Control,"[6] uses a commutator with each rotor winding. Consequently, when the transmitting rotor is turned, the receiver follows in a step-by-step rotation, one step for each commutator segment as it passes the brushes. The advantage of this is that there is no slip between the transmitter and receiver rotation. Both, when rotating, are at all times locked into step-by-step synchronism.

SYNCHRONISATION

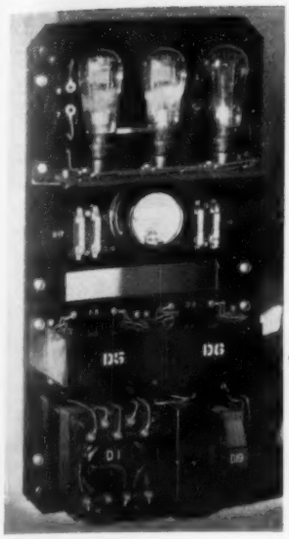
In most synchronising systems the indication-originating element actuates a follow-up system which keeps an apparatus at the receiving end in synchronism with it. There are many methods of putting this principle into practice already developed, and many more coming as a result of synchronisation developments in television.

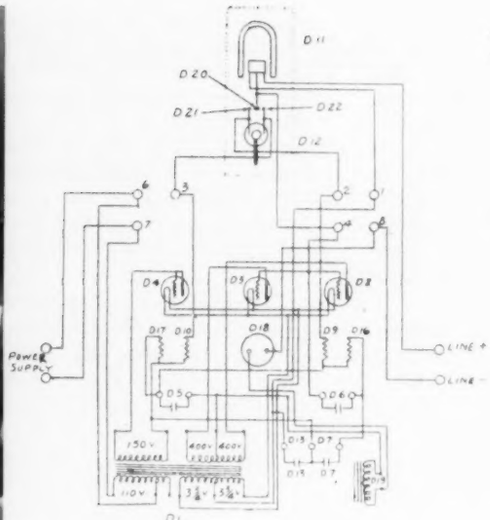


The main index of the Midworth Distant Repeater is followed-up by an ammeter pointer which closes a circuit when not directly under the index, and thereby causes the current through it to be automatically adjusted to bring it under the index. Other ammeters in series with it repeat the same indication at the distant points where they are located.

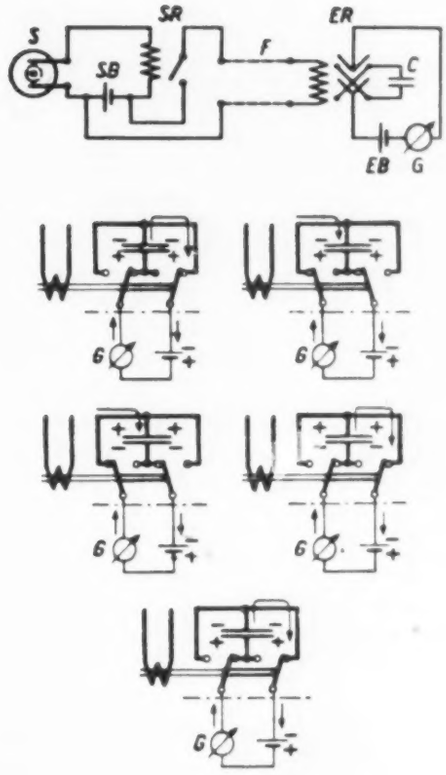


Current-reversal impulses produced by the transmitter of the Sangamo Distant Dial are counted at the receiver by a polarised-relay impulse motor. The commutator arrangement shown permits totalising readings from several transmitters, each represented by a commutator shaft.





Esterline Angus Company's vacuum tube arrangement for telemetering on the index follow-up principle.



The current impulse system uses as transmitter an induction meter, carrying on its shaft an interruptor in the shape of a commutator. In the case of remote indications the interruptor of the transmitter actuates a relay, which transmits the impulses over the long-distance line. The impulses from the transmitter in the Siemens-Halske arrangement actuate a relay contained in the receiver, which, by attracting and releasing an armature, causes a continual reversal in the charge of a condenser. The diagrams explain this process clearly. It will be seen from the diagrams that the charging currents always flow in the same direction through the indicating instrument. The frequency of the reversals is measured by means of a sluggish moving-coil instrument according to the ballistic method.

A whole group of telemetering systems operate on the method of synchronisation embodied in the Midworth Repeater.[5] The indication-originating element is an index moving over the scale of an ammeter, but actuated by the primary element — a pressure gage, for example. On either side of the index is mounted an electrical contact. The meter pointer, touching one of these contacts or the other, closes a circuit causing a motor to run in one direction or the other, depending on which side of the index the contact was closed. This motor rotates a variable resistance and so changes the circuit current that the meter pointer turns till it is exactly under the index, when both contacts are opened and the motor stops.

In series with this meter, whose pointer automatically follows up the indication-originating index, are one or more ammeters used as repeaters. Being all in series, they all carry and indicate the same current as the transmitting ammeter; therefore follow and indicate the index position.

This method of follow-up is used in the Esterline Angus system, but instead of a motor-driven variable resistance they use a vacuum-tube hook-up for regulating the transmission current.

An illustration of systems utilising a synchronous motor follow-up is the telemetering system of the Deutsche Telephonwerke.[1] A synchronous motor rotates a contact which keeps the transmission line circuit closed till the contact passes the angular position of the transmitter pointer. This closed circuit holds a relay at the receiver station locked so it couples a continuously rotating synchronous rotor shaft to a meter pointer. As long as the relay is closed, the receiver pointer is coupled to, and rotated by, the synchronous motor. When the circuit is opened, the receiver pointer is uncoupled from the motor and comes to rest at the same angular position as the transmitter pointer.

SELECTION

The most prominent telemetering systems operating on the principle of selection are the one which selects by the grouping of transmitted impulses, and another which selects by the number, or counting, of impulses transmitted.

The Telefunken Company of Germany developed an impulse-grouping system which counts the number of impulses sent in unit time by a transmitter, and selects an indication accordingly.[1] This is essentially an adaptation to telemetering of the automatic telephone dialing system.

Systems selecting an indication by counting the number of impulses transmitted afford perhaps the widest possibilities for control application. The impulses can be passed through transformers and repeating coils, so available power and phone lines can be used for transmission channels. Furthermore, since it is only the impulse of current that is counted, not its magnitude or duration, the system is largely independent of line and power supply variations.

Simplest of these systems is the Sangamo "Distant Dial." Revolutions of the primary meter are converted into impulses of current reversal, and these impulses are counted at the receiver by the rotation of an impulse-operated motor. By reversing the current to produce each impulse, instead of just starting and stopping it, it is possible, with the ingenious commutator arrangement used (see illustration) to connect several primary meters in parallel and to totalise their readings at the receiver without interference between their respective impulses.

In the Siemens & Halske system, the indication-originating element—for example the rotor of a watt-meter—rotates a commutator which opens and closes the line circuit. At the receiver end is a relay operated by the line current. With every current impulse in the line this relay operates a counter. In a modification of this type the relay sends a current from a local battery first in one direction to charge a fixed condenser, then in the opposite direction. The meter G then reads an average current depending on the *frequency* of condenser charges and discharges, thereby indicating at the receiver end the speed of rotation of the wattmeter rotor.

Westinghouse also uses current-interruption impulses. A notching relay is used to count the received impulses by advancing a gear train one step after each impulse.

For totalising readings of several transmitters the impulses from the different meters that might occur simultaneously are arranged to come in sequence by a complicated arrangement of motor-operated and selective relays.

The obvious limitation of this method is that the indications to be transmitted have to be converted into rotation speed of the transmitter's commutator. On the other hand, there is an obvious advantage in that the received relay impulses, when made to operate a counter, can totalise the metered quantities at the receiving point. In the case of the transmitter being a wattmeter, the totalisation of its power readings would indicate electrical energy; a feature of very considerable value for power network supervision or—should the commutator speed be proportional to rate of steam flow—the totalised readings would indicate at the receiver total steam consumed. A further advantage besides the possibility of totalising readings from several transmitters at one receiver, is that indications from one transmitter can be received by several repeaters.

Only the high spots in telemetering have been covered in this brief review, but these are enough to indicate that the telemetering art has already progressed so far that, using any one of the four basic principles—circuit variation, balance, synchronisation or selection, it is possible to obtain:

1. Economy of transmission line cost by utilising available power or communication lines.
2. Transmission free from line characteristic fluctuations or voltage changes of transmission power supply.
3. Means for sending one indication to several points, or several indications to one point, and
4. Means for integrating the readings received.

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[1]Distant Transmission of Measurements (La Transmission De Mesure a Distance). V. Janicki. *Bulletin de la Societe Francaise des Electriciens*, Vol. 1, April 1931, pages 341-386.

[2]T. R. Warren, British Patent No. 353,591.

[3]Electron-Tube Telemetering System. Fitzgerald, *American Institute of Electrical Engineers Journal*, Vol. 49, July 1930, pages 513-516.

[4]Remote Repeating and Summating. *The Instrument World*, Vol. 4, Dec. 1931, pages 147-148.

[5]The Midworth Distant Repeater. *Instruments*, Vol. 2, Aug. 1929, pages 291-292.

[6]Remote Tuning Control. *Wireless World*, Vol. 28, June 17, 1931, page 649.

[7]An excellent bibliography on telemetering is given in the report of the automatic substation committee of the American Institute of Electrical Engineers in *Electrical Engineering*. Vol. 50, July 1931, section 2, pages 544-549.

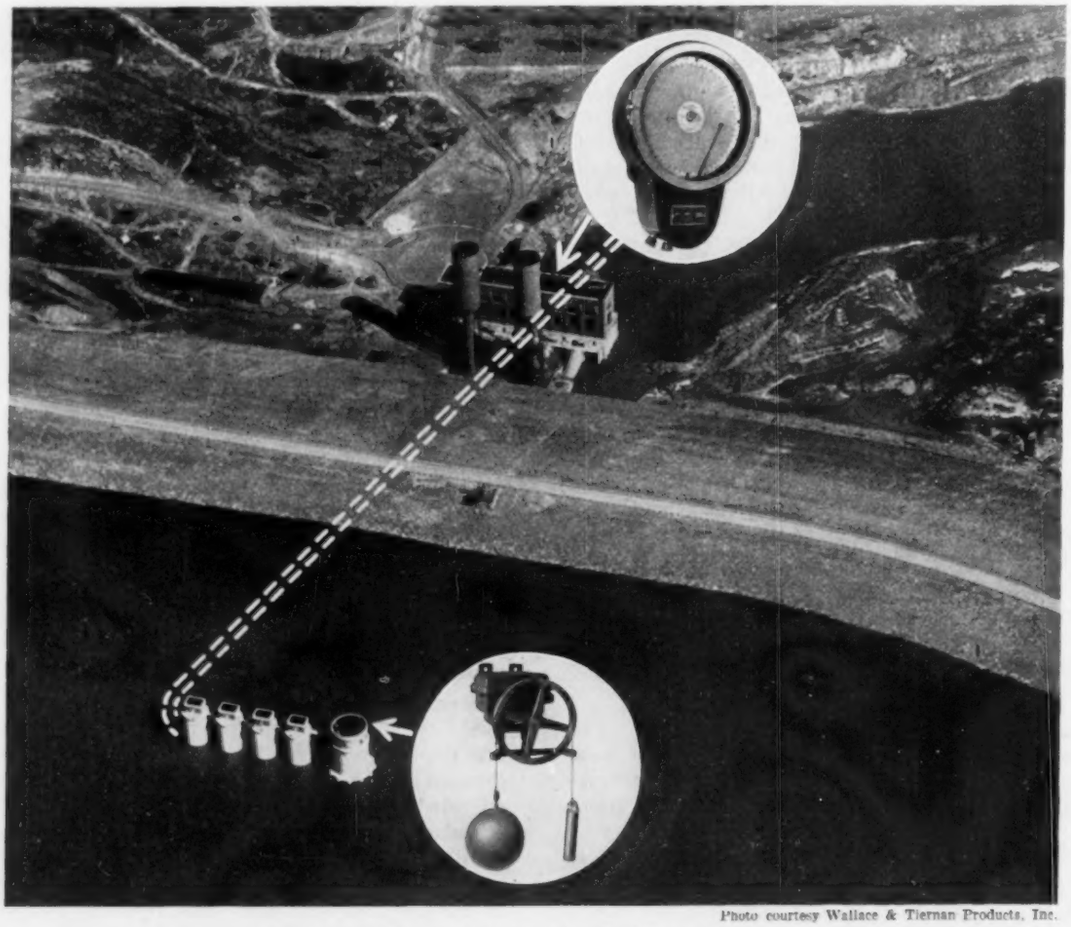

Photo courtesy Wallace & Tiernan Products, Inc.

Remote Reading of Liquid Level by Electrical Telemetering.

Flow Measurement and Control*

By M. F. BEHAR**

CHAPTER XXV
HEAD METERS
(Continued)

Fig 25-5 shows the variation of the vena contracta location for different orifice ratios. The ratio D_2/D_1 is represented by r and is the reciprocal of the ratio R used in meter constants. The coefficient Cf is the product of the coeffi-

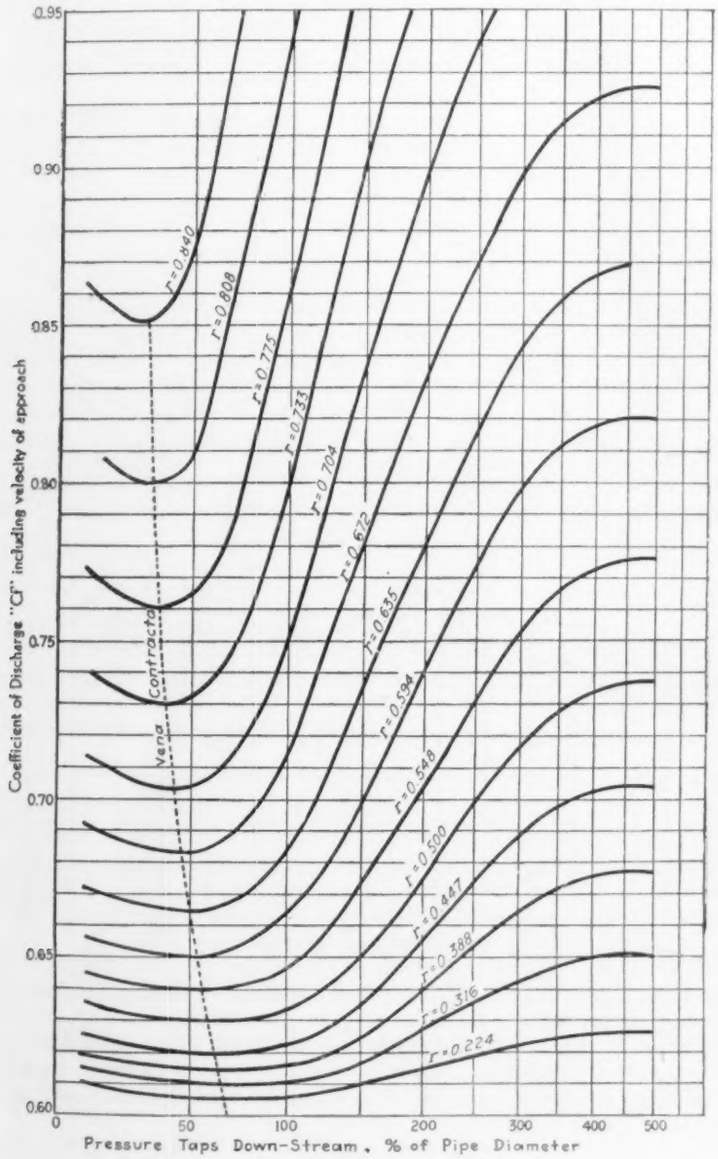

Fig. 25-5

*Part VI of *The Manual of Instrumentation.*
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PYROMETER MAN: Graduate Pennsylvania State College. Had charge of pyrometer calibration laboratory in plant with 1100 pyrometers. J-3.

ELECTRICAL ENGINEER: Graduate Charlottenburg Technische Hochschule; 8 years research engineer with chemical company; 4 years steel plant electrical engineer; can read German, French, Spanish and Italian. J-6.

INSTRUMENT SALESMAN: Mechanican Engineering Graduate; experienced sales and service most type of power plant instruments. District Sales Manager 5 years. Experience on gages, flow meter, CO_2 recorders, pyrometers and other testing equipment. J-8.

PYROMETER MAN: 8 years experience; expert electrician and gage (hydraulic, pressure, vacuum, etc.) service man; 3 years instrument laboratory; education equivalent two years of engineering college. J-9.

INSTRUMENT ENGINEER: Graduate Engineering College. Charge of instrument department in large industrial plant for 2½ years. J-10.

RADIO OPERATOR: Graduate Dodge Institute, 1917. Commercial license either broadcast or telegraph. J-12.

INSTRUMENT SALESMAN: Graduate M.E., 4 years control instruments, 2 years power plant specialties, 4 years manufacturing experience, in shop. Now N. Y. District Mgr. large rolling mill. J-13.

PHYSICIST: Ph.D. 1927. Experienced in electric and magnetic measurements, testing and research. J-14.

PRECISION INSTRUMENT MAKER: 28 years experience on scientific and geophysical instruments. J-15.

RADIO ENGINEER: Graduate University of Illinois; 2½ years experience in radio set circuit and tube measurements as well as development, design and patent investigation work. J-16.

ELECTRICAL METER and INSTRUMENT MAN: Technical graduate, 8 years in instrument laboratory of electrical manufacturing company. J-17.

INSTRUMENT ENGINEER: 2 years university, 5 years public utility, 2 years sales and service large recording and controlling instrument manufacturer. J-18.

INSTRUMENT MAKER: Engineering and Drafting instruments, 20 years shop experience, Master Degree Guild of Nuremburg. J-19.

ELECTRICAL ENGINEER: Graduate Purdue University. Experience with Telephone and Telegraph circuits, industrial control methods and equipment, and electrical instrument testing and maintenance. J-20.

AIRCRAFT INSTRUMENT MAINTENANCE ENGINEER: Formerly Service Engineer for largest manufacturer of aircraft instruments. Especially familiar with airplane instrument problems. J-21.

cient of contraction c and the velocity of approach factor f. This combined coefficient is equal to CM/A_2.

The values of the coefficient C for various values of r are given graphically in Fig. 25-6, which is due to Bailey who therein gives other useful data.

The values of the coefficient for the venturi and nozzle decrease somewhat at lower velocities due to the effect of friction.

The Venturi discharge coefficients for water at 60° F are given in Fig. 25-7, and for air at 60° F and one atmosphere in Fig. 25-8. C is defined from $V = CM\sqrt{2gh}$.

The flow nozzle discharge coefficients are given graphically in Fig. 25-9. The variations with diameter ratio and with pipe diameter are greater than for Venturi tubes, but the values are substantially the same. This figure shows also the overall loss in head due to metering by the use of nozzles of different diameter ratios.

There has been considerable discussion regarding the "law of similarity" which, briefly, states that for geometrically similar orifices, the discharge coefficient is the same regardless of absolute size. It is needless to consider the subject here. From the actual test results of various investigators, it appears that the coefficient is a function of the pipe diameter, whether due to non-similarity

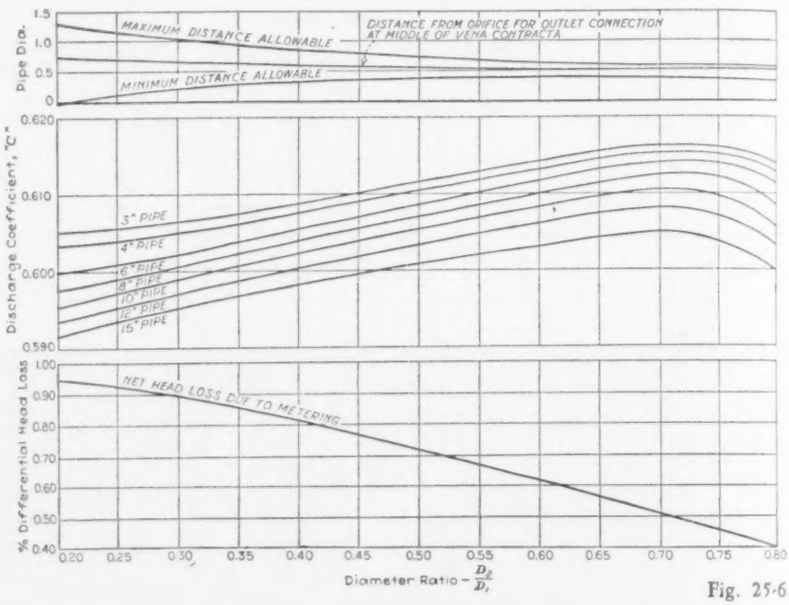

Fig. 25-6

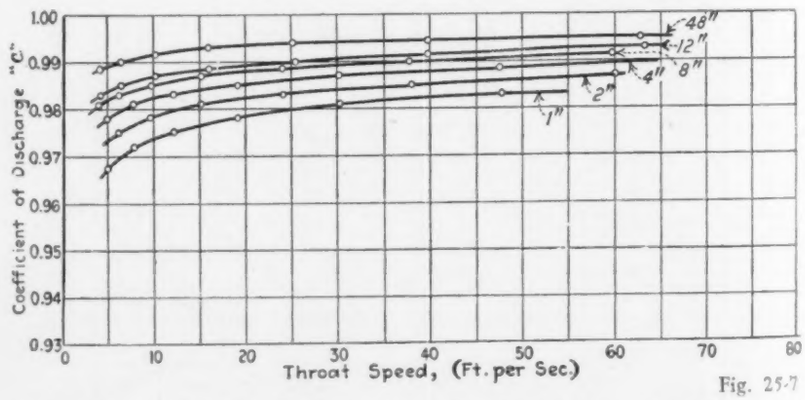

Fig. 25-7

in the test set-up (which duplicates actual installation) or to the fallibility of the law of similarity.

For orifice design and operation, the use of C_3 and C_4 as defined above in equations (3*a*) and (4*a*) is recommended. Equation (4*a*) is the most convenient for designing an orifice for a given condition because the equation may be written

$$C_3 = W/359.16\, d_1^2 \sqrt{H\gamma},$$

where all of the factors in the right-hand member of the equation are known. Then from the value of C_3' the orifice ratio can be determined from suitable curves and the orifice diameter calculated.

For the venturi and nozzle with a fixed design, equation (1*a*) is ordinarily used, using coefficients of 0.95 to 1.00.

For the pitot tube, equation (4*a*) may be used,

$$W = 359.16\, d_1^2 \sqrt{H\gamma},$$

the value of C in this case varying with the construction of the tube. The correct value for a given design is determined experimentally and is furnished by the manufacturer.

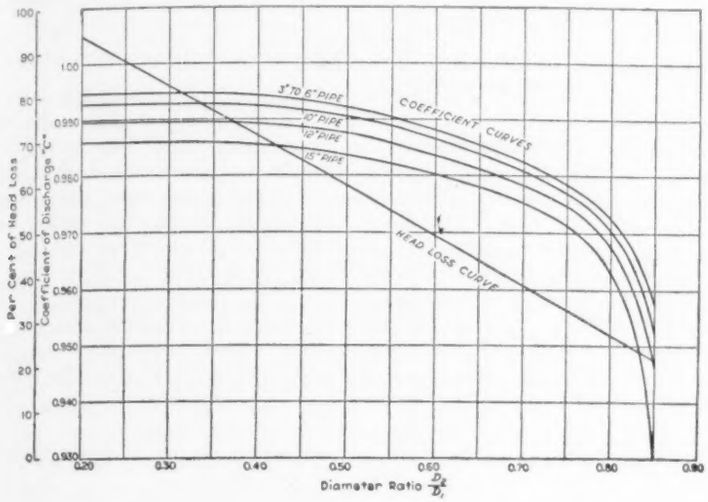

Fig. 25-9

5. Density Factor γ

The density of the flowing fluid, in lbs. per ft.^{3}, is used in the head meter calculations of the flow as given in equations (1*a*) *to* (4*a*) above. The density is generally determined by the pressure, temperature, and specific gravity of the fluid. For steam and water, values of γ may be found in all steam tables for the required pressure and temperature. For liquids other than water the specific gravity of the liquid referred to, water is used to determine the weight per cubic foot, that is, $\gamma = \gamma_w S$. When it is desired to express the flow as a volume, the equation may be modified by dividing the density factor as given by the weight per unit volume. Thus, for the flow of water in gallons, the equation becomes

$$G = 359.16\, Cd^2 \sqrt{H}\, \sqrt{\gamma}/8.33.$$

For the flow of gases, the volume is usually desired in cubic feet. In this case the equation becomes, for dry gases

$$Q = 359.16\, Cd^2 \sqrt{H}\, \sqrt{\gamma}/\gamma.$$

As given above, the volume is in cubic feet at the flowing condition, whereas it is usually to be determined at some standard condition where the weight per cubic foot is defined by the pressure, temperature and specific gravity. Thus, for a standard cubic foot of density γ_o

$$Q = 359.16\, Cd^2 \sqrt{H}\, \sqrt{\gamma}/\gamma_o.$$

The weight of a cubic foot of gas may be found by application of the gas laws except at very high pressures where the deviation from the gas laws is appreciable. In this case the actual weight per cubic foot must be found for the gas involved. For ordinary pressures the density of the gas $= .07656 \times (B/30) \times (520/460 + t)S$ where .07656 is the weight of a cubic foot of dry air at 30 in. of mercury and 60° F., B is the flowing pressure in inches of mercury absolute, t is the flowing temperature in degrees F. and S is the specific gravity of the dry gas referred to dry air.

For saturated or partially saturated gases, the volume is determined as cubic feet of dry or saturated gas at a standard pressure and temperature. Then the equation becomes

$$Q = 359.16\, Cd^2 \sqrt{H}\, \sqrt{\gamma}/\gamma_o Z$$

where γ is the same as for dry gas,

γ_o is weight of dry gas in a standard cubic foot of gas,

$\gamma_o = .07656\ (B/30)\ (520/460 + t)\ [(B - e)/B]$,

where the terms are as given above and e is the vapor pressure of the water

CHEMIST: Graduate Hunter College 1918. Spent twelve years working out various chemical processes in the laboratory and demonstrating them from a practical standpoint in paper mills. Work in the laboratory has included water analyses, some bacteriological work, fibre examination, and testing of various material. J-22.

ADVERTISING MANAGER: Also assistant sales manager of flow meter manufacturing company; available March 1. M.I.T. graduate Mechanical Engineer with 10 years shop, engineering, advertising and sales experience. J-23.

PHYSICIST: 2 years experience in research with particular training in atomics and electronics. Have held two fellowships. J-24.

COMMUNICATION ENGINEER: 10 years practical experience in installation, operation and maintenance of high frequency transmitters and receivers, also land line practice. Knowledge of Spanish. J-25.

ELECTRICAL ENGINEER: Experience with electric meter manufacturer and with an electrical testing laboratory. Master's degree in electrical engineering. J-26.

◆ ◆ ◆

MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

34 Mirror Clock. A folder describing a novel 8-day jump-hour timepiece combined with non-glare mirror. The dial figures are large and legible, white on a black background. Jaeger Watch Company, Inc., 304 East 45th Street, New York, N. Y.

35 Groundometers. Bulletin No. 120 describes a type E groundometer and some important characteristics of earth electrodes determined by groundometer measurements. Borden Electric Company, 480 Broad Street, Newark, N. J.

36 Indicator. Price Sheet No. 535 describes the Standco phase sequence indicator which consists of an aluminum disc rotor with a three phase stator winding. Herman H. Sticht & Co., 15 Park Row, New York, N. Y.

37 Microammeter. A leaflet describing an ultra-sensitive microammeter. The reverse side of this leaflet describes a differential galvanometer. Sensitive Research Instrument Co., 4545 Bronx Blvd., New York, N. Y.

38 Microphotometer. An 8 page booklet identified as MF 29 shows a Moll recording microphotometer intended for the investigation of photographed spectra. P. J. Kipp & Zonen, Delft, Holland.

39 Bakelite Review. Vol. 3 No. 4 of this publication features the following articles: "Change is the Key to Recovery"; "High Speed Wheels..in Production Grinding"; etc. Bakelite Corporation, 247 Park Avenue, N. Y.

40 Switches. Bulletin 726 describes high-tension across-the-line starting switches which are furnished in two sizes with a maximum rating for standard squirrel cage and high reactance squirrel cage motors of 750 h.p., 2500 volts. Allen-Bradley Company, Milwaukee, Wis.

41 The Laboratory. The feature article of Vol. 5 No. 1 of this publication is entitled "Justus von Liebig," who is known to chemists today through his achievements in organic chemistry. Fisher Scientific Co., 711 Forbes Street, Pittsburgh, Pa.

42 Portable Instruments is the title of Catalogue GEA-158D. These instruments are used for a. c. and d. c. measurements. General Electric Company, Schenectady, N. Y.

43 Cement and Metal Testing. Two artistic looking folders entitled, Setting New Standards in Cement Testing and Setting New Standards in Metal Testing. Riehle Bros. Testing Machine Co., 1424 North Ninth Street, Philadelphia, Pa.

44 Oscillographs. A catalogue entitled Oscillographs and identified as GEA-1209B describes and illustrates Six-element, General-purpose Oscillograph, Continuous-viewing Oscillograph, Two-element, Portable Oscillograph and Six-element, Automatic Oscillograph. General Electric Co., Schenectady, N. Y.

45 Electrical Instruments. Catalogue No. 32 describes super-sensitive electrical instruments for research. Sensitive Research Instrument Corp., 4545 Bronx Blvd., New York.

46 Tycos. The January 1932 issue of this publication contains the following: "Wind and Weather Influences on Insects"; "Artificial Weather for Tuberculin Production"; "Utilizing Weather Averages," etc. Taylor Instrument Companies, Rochester, N. Y.

47 Gas Service Journal. The feature article of this publication is "Sound Proof Insulation for Natural Gas Piping." Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

48 Lenses, Prisms and Reflectors. A 45 page catalogue of lenses, prisms and reflectors with other special optical items. Bausch & Lomb Optical Company, Rochester, N. Y.

49 Orifice Meters. Bulletin No. 176 entitled "Orifice Meters for Gas," describing orifice meters for gas and is of particular interest to gas measurement engineers or anyone interested in gas flow measurement. The Foxboro Company, Foxboro, Mass.

50 Manometer. Bulletin No. 17 describes Model 391 high range manometer used for checking the accuracy of large recording gas and steam meters.

51 Radiography. The January and February combined issues of Radiography and Clinical Photography contain the following articles: "Apostles of Science"; "Pioneering in Radiology"; "Regional Radiographic Technic," etc. Eastman Kodak Company, Rochester, N. Y.

52 Micromax. Catalogue No. 87 describing "Micromax, the improved potentiometer pyrometer." Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.

53 Optical and Industrial Instruments. A looseleaf folder describing current meter and tide gauge for distant reading. American Askania Corporation, 1603 South Michigan Avenue, Chicago, Ill.

54 Sperryscope. Vol. 6 No. 7 of this publication features the article "With Sperry Searchlights on the Bosphorus." Sperry Gyroscope Company, Inc., Manhattan Bridge Plaza, Brooklyn, N. Y.

55 Register. A leaflet describing a stock control register system which controls and safeguards the merchant's stock in detail from the time each piece is received until sold. Ohmer Register Co., Dayton, Ohio.

56 Operating Valves. Bulletin No. 24 contains 32 pages of information and description on hydraulic operating valves. Baldwin-Southwark Corporation, Paschall Station, Philadelphia.

57 Water Works Journal. The January, 1932, issue of this publication features the following: "The Water Works Man and the Public"; "History of the Sioux City Water Works," etc. Pittsburgh Equitable Meter Co., 400 Lexington Avenue, Pittsburgh, Pa.

58 Microscope Record. January, 1932, No. 25 contains the following articles: "The Microscope in the Service of Textiles: Fibre Microscopy"; "Permanent Fluid Mounts," etc. W. Watson & Sons, Ltd., 313 High Holborn, London W. C. 1, England.

INSTRUMENTS, 3619 Forbes St., Pittsburgh, Pa.

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

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Name.....

Position.....

Firm.....

Street and No.....

City.....State.....

vapor at the temperature t. Z is a factor correcting for the weight of water vapor in the gas. Its numerical value is

$$Z = \sqrt{1 + (k/s - 1)e/B} \Big/ 1 + (k/s)\left(\frac{e}{B - e}\right),$$

where k is the specific gravity of the water vapor,
s is the specific gravity of the dry gas,
e is the vapor pressure of water at the dew-point temperature of the gas,
B is the absolute pressure.

6. Limitation of Head Meter Formulae

(1) *Compressible Fluids.* As given above, the equations are limited to measurement of incompressible non-viscous fluids flowing in a straight pipe, free from pulsations. For compressible fluids, a correction factor may be required where the differential pressure is greater than 2 per cent of the absolute static pressure. The correction factor is a function of the orifice ratio, the pressure ratio and the specific heats of the fluid. In practical metering it is seldom necessary to apply correction factors for compressibility except in the case of steam at moderate pressures (up to 150 lbs.). For gases the effect of pressure loss through the primary element usually limits the pressure ratio to less than 1 percent. Table VI-3 gives the theoretical correction factors for compressibility for superheated steam at various orifices. Experimental values of these correction factors have been shown by recent investigations to be somewhat greater than the theoretical, but the actual values are not available at the present time.

TABLE VI-3—SUPERHEATED STEAM COMPRESSIBILITY CORRECTION FACTORS

$\left(\frac{p_1 - p_2}{p_1}\right)$	Orifice Ratios $d_2{}^2/d_1{}^2$						
	0.10	0.20	0.30	0.40	0.50	0.60	0.70
0.01	0.994	0.994	0.993	0.993	0.992	0.991	0.989
0.02	0.988	0.988	0.987	0.985	0.983	0.980	0.975
0.03	0.982	0.981	0.980	0.978	0.975	0.970	0.965
0.04	0.976	0.975	0.974	0.971	0.967	0.961	0.950
0.05	0.970	0.969	0.967	0.964	0.960	0.950	0.939
0.06	0.964	0.963	0.960	0.956	0.950	0.941	0.925
0.07	0.957	0.956	0.953	0.949	0.942	0.931	0.915
0.08	0.951	0.949	0.947	0.942	0.935	0.922	0.902
0.09	0.945	0.944	0.940	0.934	0.925	0.912	0.890
0.10	0.939	0.937	0.933	0.927	0.918	0.902	0.880

(2) *Viscous Flows.* The application of the hydraulic equation of flow as given is applicable in general to liquids whose kinematic viscosity does not exceed 15 centipoise (about 80 seconds Saybolt). The limiting factor is usually given as $Vd\ \gamma/\mu > 10{,}000$
where V = velocity,
d = pipe diameter,
γ = specific gravity,
μ = viscosity.

The expression is dimensionless when all factors are expressed in the same units. For greater values of the "Reynolds' number" the discharge coefficient of the primary element varies and accurate results cannot be expected except where the flow is constant and the necessary corrections are made for the actual conditions.

(3) *Pulsating Flows.* The effect of pulsations in the flow due to the action of reciprocating engines, pumps, etc., causes too high a reading of the head meters. To measure such flows with any degree of accuracy the pulsation must be removed or reduced as much as possible. This is accomplished by installing expansion chambers or restrictions, or both, between the source of pulsation and the primary element. (For liquids, a restriction alone is of no value, an air chamber is required.)

(4) *High Differentials.* The equations given for flow measurement apply to differential pressures less than 43 percent of the inlet pressure of steam and 47 percent of the inlet pressure for gases. For higher differentials, the discharge becomes a function of the inlet pressure alone and is independent of the lower pressure. This condition is very seldom encountered in practical metering.

NEW INSTRUMENTS

Recently Developed by Manufacturers

Write Information Section, Instruments Publishing Company, for additional Information.

Varying-Pressure Flow Meter

American Askania Corporation

TO MEASURE flow of gases where they change materially in pressure and temperature, this instrument uses the following principle. A part of the flow, proportional to the total flow, is diverted and reduced to atmospheric temperature and pressure. This by-passed flow, converted to atmospheric pressure and temperature, is then measured by means of the usual instruments. How the principle is applied in practice is illustrated in Fig. 1. A measuring resistance —which may be either an orifice plate, nozzle, or venturi tube—is built into the main the flow through which it is required to measure. This resistance gives rise to a differential pressure, p_1—p_2, when there is a flow of gas.

The measuring connections are joined to the flow deviator, which contains two chambers n and o, separated by a very sensitive diaphragm. This diaphragm is connected to a small outlet valve (needle valve) q. The measuring connection p_1 in front of the orifice plate leads to chamber o, whilst the connection p_2 leads to n. In the measuring connections there are two small orifices plates l and m, which are equal in size. Whilst l performs an important function in the actual process of measurement, the purpose of m is merely to synchronise the filling of the two chambers n and o and

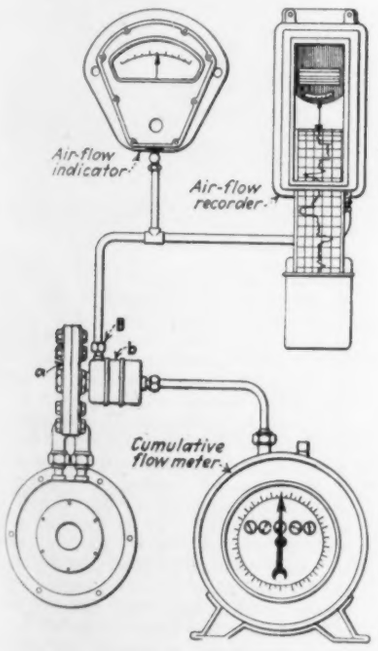

Fig. 2

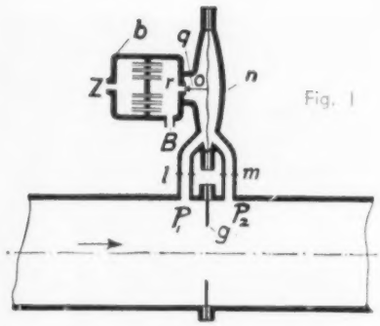

Fig. 1

to prevent overloading of one side of the diaphragm where the flow is first started or any sudden change in the pressure occurs. This obviates any damage to the diaphragm or the needle valve.

As soon as air or gas begins to flow through the main pipe, pressures p_1 and p_2 respectively are set up at the two measuring connections and are immediately communicated to the diaphragm. Pressure p_1 in the chamber o (being greater than p_2) deflects the diaphragm to the right and thereby opens the needle valve q until a sufficient volume of air or gas has escaped through it to equalize the pressure at p_2 in the two chambers o and n. The effect of this is that *in front of* orifice plates g and l (reading in the direction of the flow) the pressure (p_1) is the same, while behind g and l, the pressure (p_2) is also equal. The two orifice plates are accordingly subjected to exactly the same conditions of flow, the differential pressure as well as the static pressures and the temperatures being the same at both points; the constants which apply are therefore equal in both cases, so that a definite proportion of the total flow carried by the main pipe passes l, such proportion being governed by the relation between the two resistances opposed to the flow. The dimensions and calibration of the orifice plates l and g are so arranged that the volume of air or gas passing through l shall be 0.001, 0.0001, or any convenient fraction of the main flow passing through g which serves the purpose best.

The by-pass flow passing over the orifice plate l and through the needle valve q is measured, and only needs multiplying by the orifice plate factor for the volume of the main flow to be ascertained.

If nothing is desired beyond a progressive indication of the total volume of the flow, the by-passed flow passing through the needle valve q is carried through a pipe direct to a meter built on the lines of the ordinary domestic or experimental gas meter. As the small deviated flow quickly adjusts itself to the outside temperature and atmospheric pressure, the use of a meter of the recognized type which has passed the usual official tests will give reliable indications in terms of the prevailing atmospheric conditions.

The actual volume of the flow which is passing is determined with the assistance of the capillary cartridge b, which is either screwed permanently to the flow deviator (for use with gases differing but slightly in temperature from the surrounding atmosphere) or else fitted in at a sufficient distance behind the needle valve q. The effect of the resistance set up by the capillary cartridge is to break up the flow into straight line streams (laminated flow), so that the pressure in the chamber r, necessary to overcome this resistance, is directly proportional to the volume of the flow. This pressure is taken off at the point B, and pressure gauges or recorders can be connected and calibrated to show the volume of the by-passed flow in cubic feet or in litres per minute. The by-passed flow, having passed through the capillary cartridge, is either allowed to escape into the atmosphere at Z or else it is led on to a meter.

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Universal Testing Machine

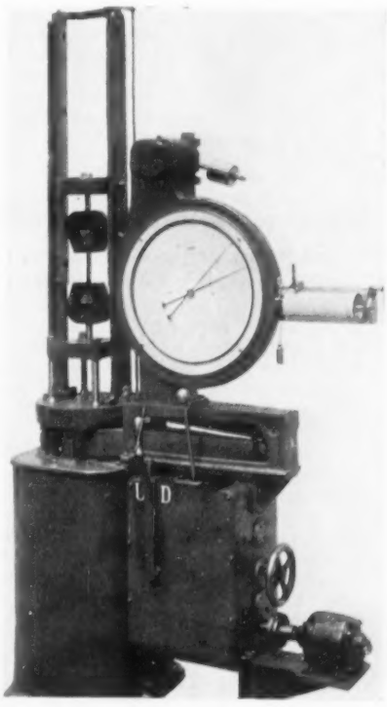
Tinius Olsen Testing Machine Co.

VERY SIMILAR to an earlier machine by this company, but incorporating new features, this new testing machine has a gear drive with four speed automative gear box. Gears are always in mesh, and can be shifted without operating neutral control lever.

By means of the hand wheels at right of the gear box, the machine may be operated by hand when desired up to its full capacity for applying very fine increments of load to specimen or for any hand adjustment of the moving crosshead when desired.

The dial is not hydraulic, but is *mechanically operated* under control of a lever and a pendulum primary weighing system. The dial is large and pointer can make two complete revolutions, providing equivalent to two dials in one, and enabling operator to read correspondingly small increments of load.

The weighing table rests on knife edges in levers. Through a system of levers the load is transmitted to a pendulum on back of upright housing at rear of dial. The amount of movement of this pendulum is shown by pointer on dial which is marked so as to read direct the number of pounds load being applied to test specimen. On the dial are two pointers, one of which moves forward or



backward constantly as load is increased or reduced. The second pointer is drawn forward by the first pointer and always indicates the maximum load which has been applied to specimen. The yield points are thereby shown clearly and when specimen breaks the second pointer remains at breaking load until set back by the operator.

The autographic attachment shown at the right of the dial uses standard sheet of cross section paper 8½" x 11" and automatically provides a record of each test.

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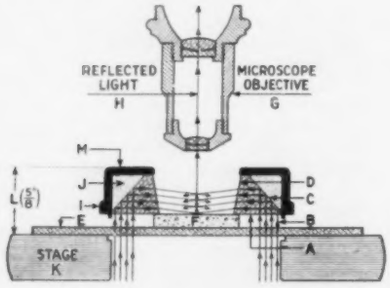
Microscope Illuminator

Superior Microscope Illuminator Co.

IN viewing an object under a microscope, a true view of its contour or the nature of its surface requires that the object be illuminated with diffuse light —or light coming equally from all directions. Such a distribution of light is obtained with this illuminator, which consists of an optical medium (A) that completely surrounds the object under study (F). The light enters at the surface (B), is totally reflected at the silvered surface (C), and is finally refracted at the surface (D), and thus directed down from all sides upon the object under study, (F), which rests upon the glass slide (E).



Any convenient source of light may be used, including sunlight, at any desired intensity. By suitable manipulation of the light source a "spot" or light or shadow can be produced at any point on the object, permitting detail study of the surface or its contour.

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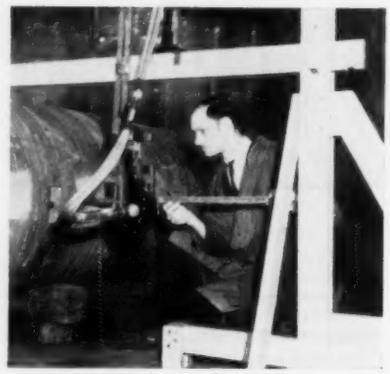
Industrial X-Ray Apparatus

General Electric X-Ray Corp.

A 200,000-volt X-ray tube is used, the highest voltage rating commercially available, the equipment being the standard hospital deep therapy type built and installed by the above company. Products varying in size from very small devices to castings weighing many tons can be photographed.

In operation the piece to be photographed is set in place, the film put in position and the X-ray tube placed at the proper point by means of an overhead suspension system. Because of the high-voltage X-rays employed, the rooms containing the apparatus are very carefully shielded with lead lining on the roof and walls, lead sheets ¼ and ⅛ ins. thick being used and held in place by lead-headed pins. This lead lining extends into the ground about 4 inches. While the X-ray photograph is being made the operator can watch the equipment through a suitably located window of lead glass. Experience has shown that it is desirable to give a 5-minute exposure at low voltage in making pictures where a longer time is not needed, as more "contrasty" pictures are produced at the lower voltage. Where it is necessary to make longer exposures because of the nature of the work, the voltage is increased to the full 200,000 and the time extended as necessary.



One of the accessories in the laboratory which has been found particularly valuable is a sterescopic viewing equipment. By taking two x-ray photographs from slightly different positions in a manner analagous to the operation of a pair of human eyes, and then placing the negatives in this equipment, an effect of depth is created. Thus the analyst can look into the casting or device and see structural details in their proper relative positions.

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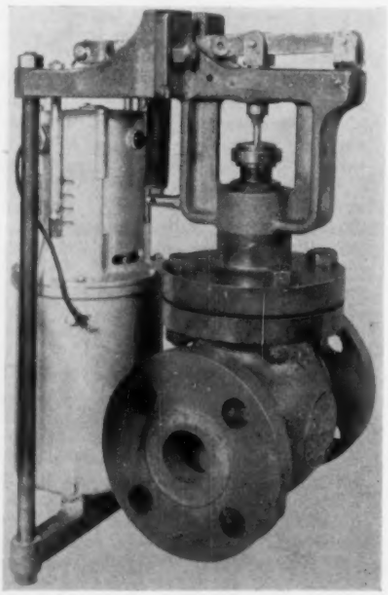
Valve Motor for Remote Control

General Electric Company

DESIGNED for general industrial applications, as in oil refineries, paper mills, etc., this new Thrustor-operated valve enables centralized remote control of gases or liquids under pressure.

In operation, the Thrustor, a self-contained power unit consisting of a motor controlling an improved hydraulic cylinder, applies pressure to the valve to open or close it. A spring is used to return the Thrustor to its original position.



The Thrustor is readily adjustable for rapidly or slowly opening valves. It is frequently desirable to close a valve rather slowly particularly where there is high pressure to give high velocity flow in pipe lines. This is easily accomplished by controlling the flow of oil from under the plunger of the Thrustor by means of an external adjustment. By this means the valve can be made to close slowly without shock or hammer in the pipe line. The Thrustor type valve is positive in opening and closing, since it is direct-connected, and requires less time than a motor valve to operate. In addition, no overload protection is necessary in the motor circuit of the Thrustor, since the Thrustor can go to the extreme limit of its travel without overloading the motor. No limit switches are necessary for controlling the opening or closing of the valve. Because of the small amount of current consumed by the Thrustor motor, a small relay may be used to handle the unit.

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Wide Field Microscope

Bausch & Lomb Optical Co.

THIS new instrument is similar to other of the company's wide field, binocular microscopes but is mounted on a laboratory stand with substage mirror which greatly broadens the range of its application. The stage is glass; thus either opaque or transparent specimens can be observed. The microscope, being removable from the base, can be placed on objects too large for the stage to accommodate, making the instrument particularly adapted for microscopic inspection of large or bulky specimens, evidence of wear, or for surface cracks and blow holes. The binocular eyepieces are inclined at an eye-level angle to give greater ease in operation. And five pairs of objectives are interchangeable in the revolvable drum nose-piece to provide stereoscopic vision and give a range of magnifications from 0.7 × to 87 ×.

Boiler Water Test-O-Meter

E. Edelman & Co.

CONCENTRATION of mineral salts dissolved in boiler water is of importance to the power-plant engineer. This boiler Test-O-Meter provides power plant operators with a quick, ready apparatus for determining this mineral salt concentration.

The instrument comprises a container to hold the sample of boiler-water, and a thermometer with a 60° to 120° F. scale. A conversion table and correction scale are also built into the instrument, so concentration of the mineral salts can be read directly in grains per U. S. gallon or parts per million.

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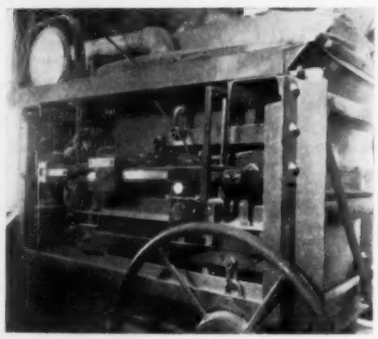
Photo-Electric Scale Control

General Electric Co.

THE SCALE beam is set for the weight desired by means of a poise. A light source is set directly back of the beam and the photoelectric relay is six feet in front of it. Cement is fed into the hopper and, when the proper weight is reached, the beam rises, exposing the



light source and energizing the photoelectric relay. This causes the opening of a control circuit to the cement feed motor and automatically shuts off the supply.

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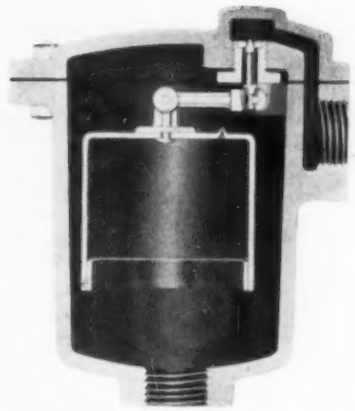
Self-Venting Steam Trap

J. P. Marsh & Co.

THIS self-venting inverted bucket steam trap, with a large water capacity, is designed for installation on kitchen and hospital equipment or any service where considerable volume of condensate is to be handled.

The trap, which is simple in construction and operation, discharges intermittently. Between cycles of operation the float is in the raised position being filled



with steam and air and the valve pin is closed against the seat. After condensate rises in the trap body, the weight of the water forces the steam and air out through the vent opening in the top of the float, causing the latter to drop. When the condensate has drained from the trap, it fills with steam, causing the float to rise once more and the valve pin to close against the seat.

All piping connections are made to the body, which permits removal of the trap cover without disturbing piping. The entire operating mechanism lifts out with the trap cover, making all parts easily accessible. The trap, made in several sizes, is suitable for working pressures up to 125 lbs./in.^{2}

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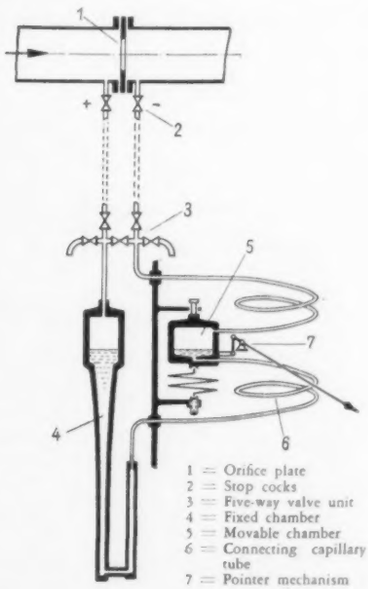
Volume Meter for High Pressures

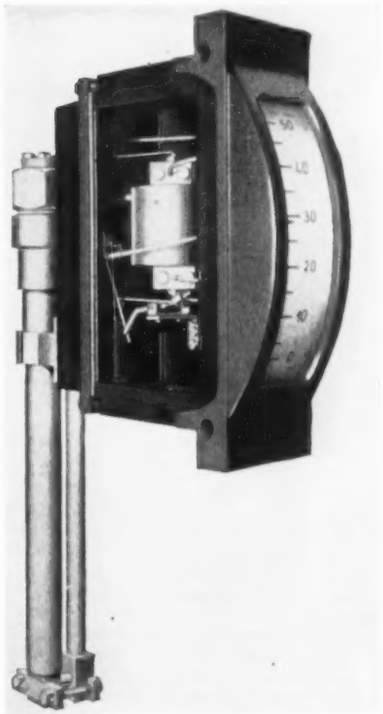
American Askania Corporation

THE MERCURY-BALANCE principle on which this meter works is as follows: The high and low pressures created by the orifice plate are transmitted to the mercury balance via the stop cocks 2 and the five-valve unit 3. The measuring pipe marked + is connected to the fixed chamber 4; the pipe marked — is connected to the spring-supported chamber 5 by a flexible capillary tube. A second flexible capillary tube 6 connects the fixed chamber 4 to the movable chamber 5. The whole system thus forms a mercury-filled U-tube.



1 = Orifice plate
2 = Stop cocks
3 = Five-way valve unit
4 = Fixed chamber
5 = Movable chamber
6 = Connecting capillary tube
7 = Pointer mechanism

When there is no flow in the main pipe, there is no difference of pressure at the orifice plate, the mercury remains at the same level in both vessels and the pointer connected to the movable vessel through a system of levers remains in the zero position. When a difference of pressure is created, the mercury in chamber 5 will rise, the weight of the chamber will increase and will cause it to depress the supporting spring, thus deflecting the pointer.



If the bore of the fixed vessel were cylindrical, the weight of the mercury passing into the movable vessel would only correspond to the difference in pressure, that is to the square of the volume. The movement of the pointer would therefore be proportional to the square of the volume. As however a linear scale is desirable for the measurement of volumes—in the case of recording instruments this is absolutely essential so that the chart can be integrated by a planimeter—the fixed chamber 4 is fitted with a liner of parabolic section. This latter is so calculated that the quantity of mercury passing into chamber 5 is proportional to the square root of the differential pressure. The movement of the spring and consequently the pointer is therefore directly proportional to the volume.

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High Voltage X-Ray Tube

General Electric Co.

BY SUBSTITUTING a quarter-inch thickness of glass of a special nature in place of the sixty-fourth-inch thinness of the more usual glass, by changing the geometrical design, and by increasing the water-cooling of the tar-

get, this company has found it possible to increase very considerably the voltage at which an x-ray tube can be operated.

The highest-voltage x-ray tubes heretofore available commercially were operated at 200,000 volts. Operation of these thin lime-glass tubes at a higher voltage increased the danger of destruction of the tube as a result of high-voltage surges causing a break-down of the glass. It was found that a very heavy glass could be used and that, without materially increasing the dimensions of the tube, much higher voltages could be employed —it could better resist surging tendencies to which the other tube succumbed.

Even when the focal spot of the target was reduced to a small diameter for sharp focus in industrial applications, the water-cooled tube was operated satisfactorily at 340,000 volts and 10 milliamperes. Since the penetrating power of x-rays depends on wave length, and therefore on the voltage at which the tube is operated, the increase from 200,000 to 300,000 volts and higher increases the penetrating power of the x-rays and cuts down the time necessary for obtaining radiographs, or x-rays photographs.

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Motor Operated Relay

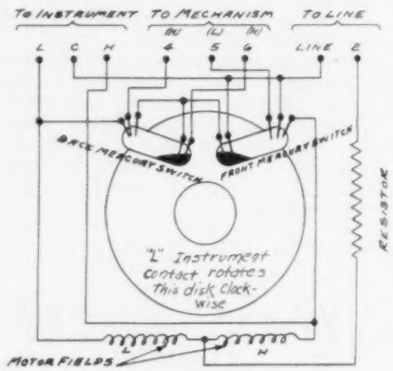
Automatic Temperature Control Co., Inc.

AS THE name "Motomerco" implies, this relay has motor operated mercury contact tubes, and was designed primarily to select one of three control circuits when actuated by an instrument having sustained contacts for low and high positions only with an intermediate no-contact position. Preferably the instrument low and high contacts should be individually adjustable to permit change in width of the intermediate no-contact or holding position to meet local conditions. The design of the relay is such that it will automatically return to its mid-position and make a control circuit when the actuating instrument is at its intermediate no-contact position.

By means of this relay, it is possible to use an instrument with a single sustained contact such as a thermometer, pressure gauge, etc., for operating two separate control circuits as required to function a two-position motor operated valve, thus eliminating the customary low position contact so that there is no interference with free movement of the instrument stylus and its true reading when conditions are such that stylus is below the control setting.

Where the Motomerco relay is to be used to operate two separate control circuits from an instrument with a single sustained contact, a simple mechanical adjustment can be provided to introduce any desired time lag up to 25 seconds, thus delaying a change in control circuits should the actuating instrument make accidental contact due to vibration or other cause.

Where it is desired to use three colored signal lights to indicate the condition of temperature, pressure or other controllable factor, and the actuating instrument has intermittent instead of sustained contacts for low, normal and high positions, respectively, the Motomerco relay can be wired as a three-position holding-in type so that it will remain in the position last energized, thus holding steadily the signal light corresponding to position of instrument stylus, without the objectionable off-and-on action which would otherwise be the case.



There are no open contacts with this relay, as all circuits are broken by mercury enclosed in glass tubes, which are sealed under gas pressure. The actuating instrument will be quite free from contact trouble, as the motor used in the relay draws but 4 watts at 110 volts a. c.

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Heavy Duty Push-Button Stations

General Electric Co.

THE push-button stations of this new line consist of one or more of the following units inclosed in a case: 1. Push button (momentary contact), 2. Selector switch (maintaining contact), and 3. Indicating-lamp receptacle. Any combination not exceeding five of these units is available in the wall-mounted stations. The same case houses the push button, selector switch or lamp receptacle.

This momentary-contact, push-button unit provides both a normally-open and a normally-closed circuit. Heavy, double-break contacts are employed and a rolling contact is obtained on both normally-open and normally-closed positions. Allowance for ample creepage distances from live parts to ground make this device suitable for operation on 600-volt circuits.

The maintaining-contact selector switches are available for operation as

single-pole, single-throw; single-pole, double-throw; or double-pole, single-throw knife switches.

In the stations employing indicating lamps 18-volt lamps with color cap are used. For higher voltage a separately mounted resistor is used in series with the lamp except in cases where a station requires a certain voltage, in which case the resistor may be included in the station.

◆ ◆ ◆

Universal Testing Machine

Toledo Precision Devices Co.

THIS universal testing machine is designed for compression, tension and transverse bending tests. The force measured is applied by a hydraulic press and transmitted through the test piece. Therefore the force measured is that applied to the test piece alone. Accurate results are assured by the use of the automatic springless pendulum type counterbalancing mechanism. It is claimed friction, oil thickness, and temperature do not affect exact results. Ease of operation is another feature. A touch on a button starts the motor. The operator can regulate the speed by turning a wheel and from the dial observes the pressure applied. In addition, this device is compact, a complete machine of 200,000 pounds capacity only occupying a space seven feet by four. Rugged construction combines durability with precision.

Additional features are: Capacities ranging from 25,000-200,000 pounds; double reversible dials on the dynamometer to increase capacity range, and graphic recorder to chart the pressure trend at every stage of the test and breaking point.

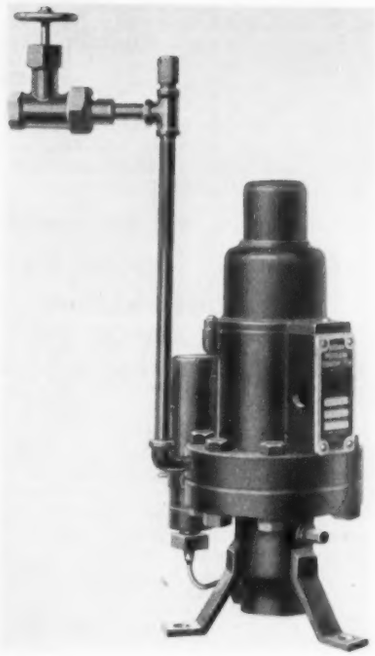
Absolute Pressure Gage

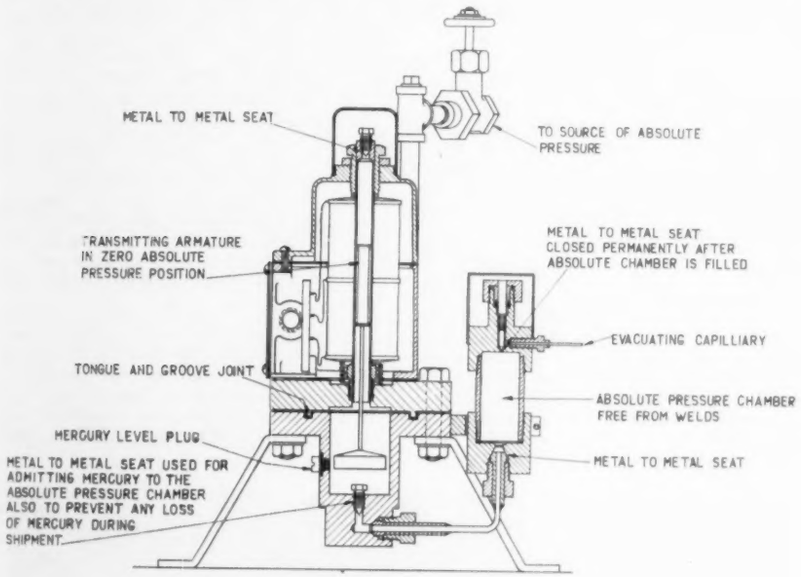
Brown Instrument Co.

IN DETERMINING the efficiency with which a steam turbine and condenser is working it is necessary to know the amount of back pressure against which the turbine is operating. This requires the measurement of absolute pressure—that is, the readings of a vacuum gage must be subtracted from the readings of a barometer.

The simplest instrument for so measuring absolute pressure is the mercury-filled U-tube. This is the principle on which operation of the Brown absolute pressure gage is based. A Brown manometer is employed which, by an application of the electrical inductance bridge, converts changes in the relative level of the mercury columns into electrical impulses, which in turn operate a pointer or recording pen-arm in the connected instrument to give the absolute pressure reading.

The instrument may be at practically any distance from the manometer, which in many installations is a great advantage to the user. These absolute pressure gages are made for service within a minimum range of 0 to 100 millimeters of mercury absolute pressure.




METAL TO METAL SEAT
TO SOURCE OF ABSOLUTE PRESSURE
TRANSMITTING ARMATURE IN ZERO ABSOLUTE PRESSURE POSITION
METAL TO METAL SEAT CLOSED PERMANENTLY AFTER ABSOLUTE CHAMBER IS FILLED
EVACUATING CAPILLIARY
TONGUE AND GROOVE JOINT
ABSOLUTE PRESSURE CHAMBER FREE FROM WELDS
MERCURY LEVEL PLUG
METAL TO METAL SEAT
METAL TO METAL SEAT USED FOR ADMITTING MERCURY TO THE ABSOLUTE PRESSURE CHAMBER ALSO TO PREVENT ANY LOSS OF MERCURY DURING SHIPMENT.

◆ ◆ ◆ ◆ ◆

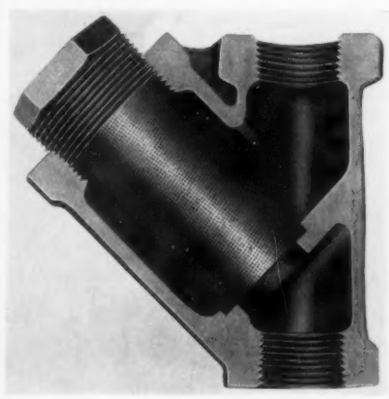
Pipe Line Strainer

Jas. P. Marsh & Co.

THIS strainer is designed for installation on return lines of low, medium and high pressure steam systems up to 125 lbs., to eliminate dirt, grit and scale. It may be installed either horizontally or vertically and is self-cleaning and draining when the plug is out or the blow-out valve is open.

The body and strainer plug are of cast iron. The strainer cylinder is a perforated truncated cone. The standard cylinder for steam, water, air, gas and oil is made of brass with 1/16" perforations. For other services cylinders of special metals and with special perforation sizes can be supplied.

The strainer is made in sizes ½" to 2" connection. All sizes are made with ½" blow-off connection.

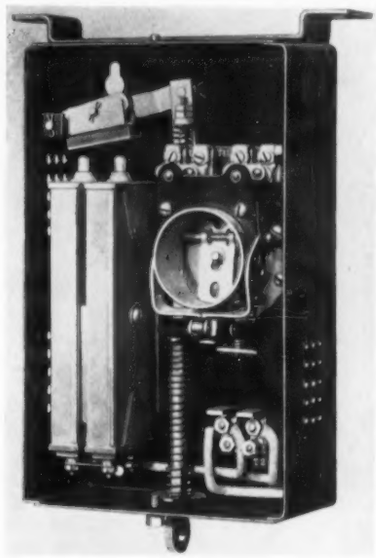


Treadle-Operated Controllers for Small Motors

Allen-Bradley Co.

THIS TYPE of treadle-operated controller provides a convenient means for smooth control of speeds of winding machines, etc., driven by direct-current or universal motors. Operation of the treadle compresses a graphite-disc compression resistor. This type of resistor allows a stepless variation in motor speed.

A self-contained disconnect switch opens the motor circuit with a quick break of the "off" point, and a self-contained short-circuiting switch by-passes the resistance at full speed.



These controllers are made in five sizes, the largest being rated at ½ HP and the smallest at 1/20 HP. The illustration shows a size D controller for treadle operation, with the cover removed. This size is mounted on the under side of a table or a machine.

◆ ◆ ◆

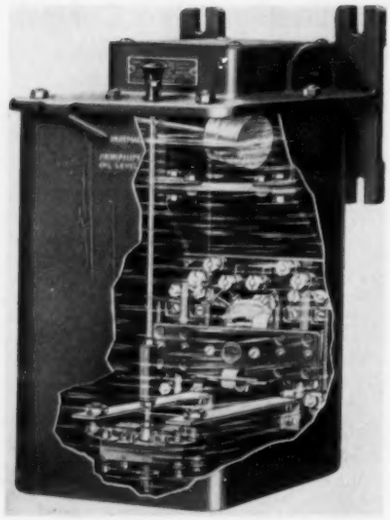
New Explosion Proof A. C. Starter

Cutler-Hammer, Inc.

DISTINGUISHING this new automatic, across-the-line starter for a. c. squirrel-cage induction motors from similar explosion proof equipment is the immersion in oil of its new thermal overload mechanism. It differs from the usual immersed oil dashpot relay and 3-pole magnetic contactor in that a newly designed thermal overload mechanism is used with the contactor.

The new starter is designed in keeping with the latest requirements of the Underwriters Laboratories for Class 1, Group D, Hazardous Locations. Briefly, this includes such installations where Duco, lacquers, gasoline, alcohol, etc., are present in the atmosphere.

The contacts of this new starter open under a 6" head of oil. A special provision is made for bringing all incoming wires to the terminals below the oil level. A float operated oil indicator shows the oil level. Threaded conduit openings and a compound filled junction box are included.



The supporting structure is arranged for wall mounting and the tank is easily removed. Being completely oil immersed, the starter is corrosion resisting and therefore suitable for chemical plants and cement mills.

◆ ◆ ◆

Seamless Metallic Tubing

Bendix Aviation Corp.

MADE of special bronze alloy seamless pipe, the Bendix hose is corrugated in round-thread single lead deep-wall form and does not contain welded, brazed or interlocked joints. It is claimed that the Bendix hose is far more flexible than existing types of metal hose because of its "deep wall" construction.

A protective casing, braided from copper, is designed to cover the hose with either one, two or three layers, depending on the pressure the hose must withstand. As a protection against mechanical damage to the braid covering and to distribute the flexing action, the manufacturer recommends use of an interlocked, unpacked galvanized steel casing over all.

The hose is being manufactured at present with internal diameters of 3/16", ¼", ⅜", ½", ¾" and 1". This new tubing finds application particularly for conveyance of liquids, steam, or gas.

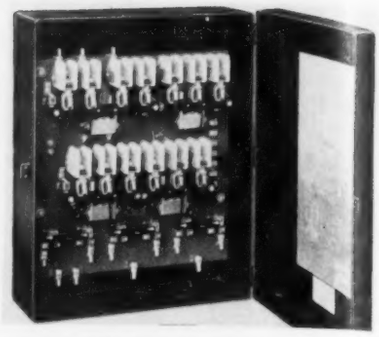
◆ ◆ ◆

Automatic Switches for Multi-Speed Motors

Allen-Bradley Co.

THESE switches consist of two or more magnetic switches operated from control stations having 3, 4, or 5 push buttons. An optional feature of these switches is a slow-speed-start interlock, which compels the operator to follow a definite sequence in starting the motor, always starting with the first speed and then advancing through the second, third, and fourth.

Complete protection against overloads is provided through the use of thermal overload relays for each speed. No-voltage protection is a standard feature with 3-wire control, and no-voltage release with 2-wire control.



These switches are for two, three or four speed, non-reversing service, in connection with 2 and 3 phase multi-speed motors of consequent-pole-winding or separate-winding type, in ratings up to 40 HP, 220 volts, and 75 HP, 440-550 volts, 25 to 60 cycles.

◆ ◆ ◆ ◆ ◆

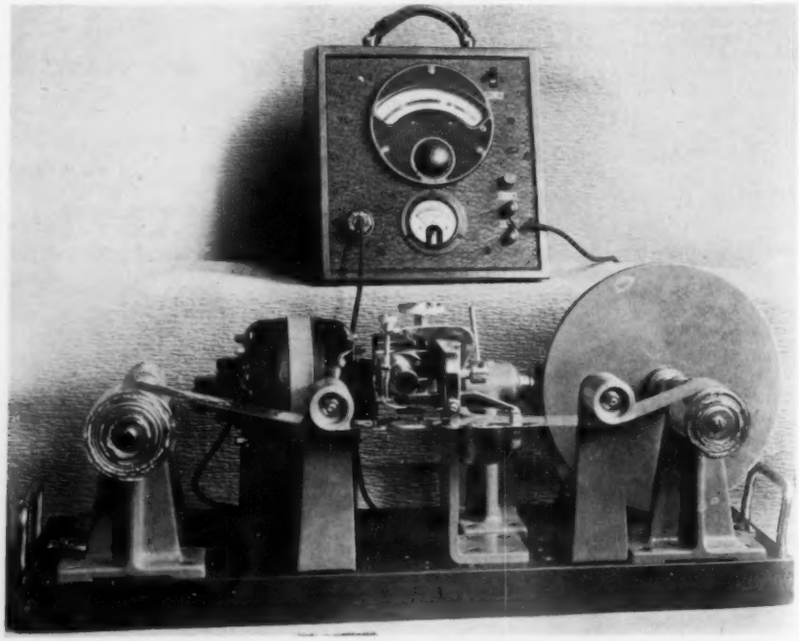
Gage for Continuous Sheet Stock

Pratt & Whitney Co.

THIS machine is intended for maintaining uniformity in the rolling of sheet and strip stock like foil, wire, paper, etc., by continuous gaging. Essentially the device is an adaptation of the company's Electrolimit gage which gives a 1" meter deflection for 0.0001" variation in the thickness of the material rolled.

Material of this general nature usually is gaged at some point between the calender rolls and the reel upon which it is wound. Idler pulleys such as are shown are employed to obtain a correct and constant elevation. The material passes between a gaging anvil of either the fixed or roller type, and a gaging contact pointer of suitable design. The latter is one end of a lever, hinged at the center, and kept in contact with the foil by a constant spring pressure. The other end of the lever is in contact with the armature lever of the Electrolimit gage head. Thus any change in thickness of the material is transmitted mechanically to the gage, and then is magnified through the electric circuit and shown in easily readable form on the indicating dials. Two gage heads can be mounted on suitable brackets on the same mill to assure uniform thickness. Wear on the gaging contacts is minimized by the use of either tungsten carbide or diamond points.

The only electric power needed to operate the gaging device is 110 volt 60 cycle current. A voltage regulator in the instrument reduces the error from line voltage changes to about a millionth of an inch per volt change, which is negligible.



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Oftentimes an abstract can fit under two or even more sections. In that case we decide who will be most interested in the article, and include it under that field of reader interest. It is our aim to so arrange the abstracts that a person interested, for example, in viscosity, will keep in touch with all the important articles in his field if he reads only section 2.10. For instance, an article on "Vacuum Tube Means of Measuring Viscosity" appears under 2.10—under "Measurement and Control of Physical Properties—viscosity," although it would also fit under section (5.4)—"Electronic Devices and their Applications."

An improvement we hope to make in the Abstracts Section in the near future is the cross-indexing of articles which fit under several sections. We suggest glancing through the whole Abstract Section. This takes but a short time, and the time so taken will be found very profitably spent.

The classification number at the end of each abstract will be of assistance in mounting them on file cards.

Negative print photostats of the original articles abstracted can be obtained at 35 cents per page plus 10 cents for mailing. The remittance should accompany the order.

CLASSIFICATIONS

(By Fields of Reader Interest)

MEASUREMENT TECHNOLOGY (1)

This section includes all matters concerning the art and science of measurement as follows:

Measurement Theory (1.1)

Under this heading will be included: definitions, precision of measurements, systems of units, and dimensional analysis.

Measurement Practice (1.2)

Covers Calibration and Standardization.

Calculation (1.3)

This does not include computation for instrument design, but covers calculations as a mode of measurement.

MEASUREMENT and CONTROL (2)

This section is devoted to those general measurement practices and control applications that are not confined to any one industry or branch of engineering. Thus temperature measurement and control, being of as much importance in chemical as in metallurgical processes, is a general field of interest to all industries and all branches of engineering.

Length, Angle, and Area, Including Surveying (2.01)
Time, Speed, and Acceleration (2.02)
Weight, Density, and Specific Gravity (2.03)
Pressure and Vacuum (2.04)
Flow and Volume (2.05)
Temperature (2.06)
Heat and Combustion (2.07)
Humidity and Moisture (2.08)
Power, Work, and Output (2.09)
Physical Properties, (Viscosity, hardness, elasticity, plasticity, surface tension, etc.) **(2.10)**

TESTING and INSPECTION (3)

Physical Testing and Inspection (including strength tests, bending, magnetic analysis, X-ray inspection, and other engineering test or inspection methods.) **(3.1)**

Production Testing and Inspection (This includes methods of testing and inspection for setting up production standards, grading, gaging, maintaining quality, etc.) **(3.2)**

Maintenance Testing and Inspection (Included here will be matters concerning standards and methods for controlling performance or service of equipment. Example—The problem of controlling long phone lines to give quality sound transmission would be included here.) **(3.3)**

ELECTRICITY and MAGNETISM (4)

Electrical Properties, Tests, Measurements, and Measuring Instruments (4.1)
Electrical Measuring Devices and Applications (4.2)
Magnetic Measurements (4.3)
Magnetic Properties Materials, and their Applications (4.4)

ELECTRONICS and RADIO (5)

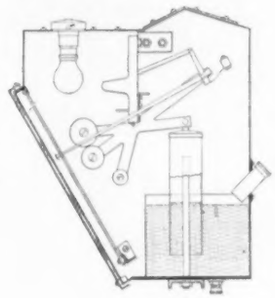
Radio Measurements (5.1)
Applications of Radio to Measurement and Control (5.2)
Photo-electric Measurements, Devices and Applications (including television) **(5.3)**

Electronic Measurements, Tubes, Devices, and their Applications (Under this heading would be included thermionic tubes, grid-glow tubes, thyratrons, neon discharge tubes, cathode-ray tubes, etc.) **(5.4)**

ACOUSTICS and VIBRATIONS (6)

Sound, Vibration, Phenomena and Measurements (6.1)
Sound and Vibration Devices or Applications (6.2)

Straight-Line Movement



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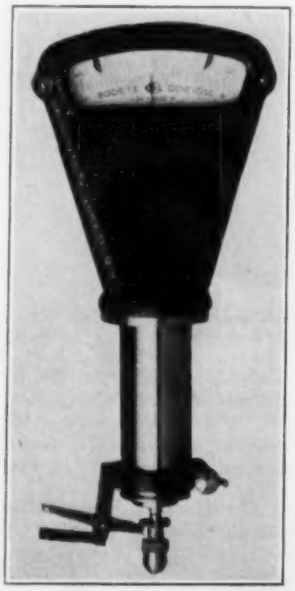

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LIGHT, OPTICS, and RAYS (7)
Light—General Measurements and Optical Applications (7.1)
Color Analysis, Color Matching (7.2)
Photometry (7.3)
Polarimetry (7.4)
Spectrometry (7.5)
Photography (7.6)
Microscopy (7.7)
Electromagnetic Rays (This heading covers all electromagnetic rays other than visible light: infra-red, heat rays, ultra-violet, X-rays, alpha, beta, gamma, cathode, and cosmic rays.) **(7.8)**

CHEMISTRY (8)
Under this heading will be chemical measurements, analysis, and their control applications.

ASTRONOMY, NAVIGATION, AVIATION (9)
Included in this section will be, besides usual matters concerning astronomy, navigation and aviation, special matter on direction-control such as range finding, direction finding, radio beacons, etc.

GEODESY, GEOLOGY (10)
In this section will be covered seismology, geophysical prospecting methods, etc.

INSTRUMENT DESIGN and CONSTRUCTION (11)
Matters concerning new instruments, their design, operation and manufacture, will be included under this heading.

GENERAL and MISCELLANEOUS (12)
This section will include: First; general items of interest to all in the field of measurement and control. Example—"Possibilities of Vacuum Tubes for Application to Measurement and Control" is an article of universal interest in the fields of measurement and control. Second; miscellaneous items of general interest because not includable under any of the above classifications. Finally, items of general interest to all fields of measurement and control, such as historical material, biographical, etc.
General (of interest to all in measurement or control fields) **(12.1)**
Miscellaneous (12.2)
Historical and Biographical (12.3)
Bibliographical (12.4)
Economic (12.5)

CONTROL FUNCTIONING EQUIPMENT (13)
Literature on the equipment used by operators or automatic controllers to perform their control functions will be covered under this heading. For example, the drum controller and associated switches, rheostats, relays, and motor starters by which an operator controls the motion of a crane are all pieces of "control functioning equipment."
Mechanical Control Functioning Equipment (13.1)
Electrical Control Functioning Equipment (13.2)
Includes drum controllers, relays, solenoids, etc.

◆ ◆ ◆ ◆ ◆

MEASUREMENT TECHNOLOGY (1)

Measurement Theory (1.1)

Investigations on the Dependance of the Accuracy of Measurements Upon Artificial Illumination. (Untersuchungen ueber die Abhaengigkeit der Messgenauigkeit von der kuenstlichen Beleuchtung.) B. REITER, *Dr. Ing. thesis, Technische Hochschule Dresden, Zeitschrift fuer Instrumentenkunde,* Vol. 50, March 1930, page 212.

Indirect illumination with large intensities yield the best results. However, a direct lighting effect should be applied in case of scales on silver, chromium and brass. E.F. (1.1)

Relations Between the Systems of Absolute and Practical Units (Die Beziehungen zwischen dem absoluten und dem wnermetechnischen Massystem.) R. HERMANN. *Zeitschrift fuer technische Physik,* Vol. 12, April 1931, pages 213-218.

Formulae for converting CGS-units into the systems with conventional units. E.F. (1.1)

Calculation (1.3)

Method of Porter for the Calculation of the Natural Vibration Frequency of Crank Shafts. (Verfahren von Porter zur Bestimmung der Eigenschwinungszahlen von Kurbelwellen.) K. SCHLAEFKE. *Zeitschrift Verein deutscher Ingenieure,* Vol. 75, Mar. 28, 1931, pages 404-405.

In order to reduce the usually rather tedious process of determining the torsional vibrations of crankshafts, Porter separates the shaft into few individual masses which are connected by massless pieces of the shaft or by pieces of uniform mass. The greater simplicity of this method as compared with the method of Wydler is illustrated by an example. Ha. (1.3)

MEASUREMENT AND CONTROL (2)

Length, Angle, and Area, Including Surveying (2.01)

Measuring Results of Invar-Wires. (Messungsergebnisse an Invar Drähten.) LAMPE, NEUMANN AND WEBER. *Zeitschrift Vermessungswesen,* Vol. 60, June 1, 1931, p. 315-322.

Several wires of Invar were measured by the National Institutes of Germany, Great Britain, and France. The methods are described and the changes in length tabulated. Ha. (2.01)

Simple Rectification of Aero-Grams for Correction and Supplementing of Maps of Large Scales. (Einfache Entzerrung von Luftbildern zur Berichtigung und Ergänzung gross massstäblicher Pläne.) KLEEMANN. *Zeitschrift Vermessungswesen,* Vol. 60, April 1, 1931, pages 206-213.

A method is described to develop from photographic surveys the actual map. Ha. (2.01)

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The Accuracy of a Fine Length Measuring with a Flat-lying Tape of a Length of 20 m. (Ueber die Genauigkeit feiner Längenmessung mit einem aufliegenden Band von 20 m Länge.) K. Luedemann, *Zeitschrift Vermessungswesen*, Vol. 60, May 15, 1931, pages 292-295.

A method is explained by which the accuracy of a measurement of total 100 m. length, when measured with a single length of 20 m., can be kept as low as ± 3 mm. for the whole length. Ha. (2.01)

Rectification Instrument for Uneven Terrain. (Entzerrungsgerät für nicht ebenes Gelände.) Otto Lacmann, *Bildmessung und Luftbildwesen*, Vol. 6, No. 1, March 1931, pages 10-12.

A new arrangement of a rectification of terrain photographed from the air is described which can be used with fairly good accuracy also for aerograms taken in uneven territories. Ha. (2.01)

The Bussole-Tachymeter. (Das Bussolen-Tachymeter.) Kurd Slawik. *Allgemeine Vermessungsnachrichten*, Vol. 43, June 24, 1931, pages 390-392.

A practical new construction of a magnetic bussole-instrument is described which can, on account of its simplicity of construction and application, often be used with greater advantage than a theodolite, especially in irregular terrain, forests, etc. The most advantageous method in surveying with this instrument is the measurement of the magnetic azimuth at every polygon point. The weight is only 2 kg, the case is 17x22x16 cm; it is made by Gust. Heyde, Dresden. Ha. (2.01)

The Influence of Temperature on the Indications of Tube-Levels. (Der Einfluss der Temperatur auf die Angabe von Rohrenlibellen.) Pinkwart. *Zeitschrift fuer Vermessungswesen*, Vol. 60, April 1, 1931, pages 187-191.

Temperature can effect changes due to the different expansion coefficients of the materials of level tube and level housing. The influences are theoretically investigated and applied to some instruments of the surveying department of Bremen. Ha. (2.01)

The Accuracy of Steel Tapes. (Die Genauigkeit von Stahlmessbändern.) Ad. Fennel. *Allgemeine Vermessungsnachrichten*, Vol. 43, Oct. 21, 1931, pages 667-670.

The equipment for testing automatically divided steel tapes is described; the tapes are made of soft steel of 0.4 mm. thickness and 12 mm. width and divided in centimeters. The errors in the divisions was within ± 0.3 mm. Ha. (2.01)

Time, Speed, and Acceleration (2.02)

Speed-Measuring Instrument. *Electrical Review*, Nov. 6, 1931, pages 708-709.

Describes C type Ashdown—"Rotoscope," introduced by A. J. Ashdown, Ltd., London. Works on stroboscopic principles, but speed is actually given as a direct reading on an engraved scale. It is driven by a clockwork motor governed by a master key control to one definite standard of speed. Operator has only to wind the instrument, and, while sighting, to turn the controller wheel until the desired view of the object is obtained. At this point its speed can be read directly from the instrument scales. The moving object is thus timed without making contact with it. The instrument is self-contained and self-driving, and is equipped with an infinitely variable speed graduation within the range 800-6000 r.p.m. MS (2.02)

A Simple Time Meter. H. B. Brooks. *Review Scientific Instruments*, Vol. 2, June 1931, p. 348-351.

For the integrating of time intervals of interrupted services the Bureau of Standards in Washington modified an ordinary telechron clock so that it integrates time intervals up to a total of 10,000 hours readible directly to 0.1 hour and by estimation to 0.01 hour. It is operated by a 60 cycle 110 volt circuit. Ha. (2.02)

The Stroboscopic Moving Pictures. H. E. Edgerton. *Electrical Engineering*, Vol. 50, May 1931, pages 327-329.

Stroboscopic observation is the most direct and straightforward method of determining angular displacement of a synchronous machine. The method requires: a disc rigidly attached to the shaft of a synchronous machine, a suitable stationary scale for recording the displacement, and an intermittent light source operating in time phase with the terminal voltage of the machine. The device produces enough light to permit a motion picture record of the angular displacement of a synchronous machine. A mercury-vapor arc produces the characteristic blue light for its powerful actinic properties. A thyratron tube containing grids controls the electric transients which are the source of the stroboscopic light. A stroboscope suitable for photographic purposes must show: (1) short duration of this light; (2) rich actinic light; and (3) reliability of light-flash control. A schematic diagram of the thyratron circuit, a thyratron arranged for taking stroboscopic movies of a 160 hp. synchronous motor, and a few strobograms are shown. WHB (2.02)

Weight, Density, and Specific Gravity (2.03)

The Weight-Indication of Transportable Scales at Improper Setting. (Die Gewichtsanzeige ortsbeweglicher Waagen bei ungenauer Aufstellung.) Karl Diehl. *Zeitschrift Verein deutscher Ingenieure*, Vol. 75, April 25, 1931, pages 519-522.

Inaccurate setting of a scale results in errors of indication which at even very slight deviation from the level are exceeding the permissible error. The errors of the inclining scales are greater than those of the beam scales. According to the degree of tilting instability may take place. The various possibilities and errors are theoretically discussed for different types of scales. Ha. (2.03)

Late Improvements in Heavy Capacity Scale Design. A. Bousfield, *Scale Journal*, Vol. 17, May, 1931, pages 9-10.

Brief description of four section and two section track scales. Ha. (2.03)

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Pressure and Vacuum (2.04)

High-Vacua in Industry. (Hochvakuum in der Technik.) A. Martos, *Chemische Apparatur*, Vol. 18, June 25, 1931, pages 133-134.

A pumping arrangement for the evacuation of large mercury arc-rectifiers of the Bergmann El. Co., Berlin, is described which can give pressures of less than 0.001 mm. Two examples for the use of such pump also in problems of analytical chemistry are given. Ha. (2.04)

Bearing Lubrication, Oil Film Pressure. *Lubrication*, Vol. 7, May-June, 1931, pages 49-60.

Apparatus is described for studying the oil film pressure within a complete journal bearing, lubricated from one end, with respect to pressure distribution, friction coefficient, journal running position at known intensities of load, journal speed and dimensions. The test results show that the pressure distribution within the oil film differed widely from the usually accepted uniform distribution. The curves show places of a negative pressure which does not contribute to the load carrying effect; and increases by the same amount the positive pressure to effect this an eccentricity of the shaft with respect to the bearing has to take place. The negative pressure could be reduced considerably by sealing the outlet end of the bearing with oil so that air could not enter the clearance space; this brought down also the positive pressure correspondingly. All tests are illustrated by curves. Ha. (2.04)

Measuring One Trillionth of an Atmosphere. Ed. K. Jaicox, *Bell Laboratories Record*, Vol. 10, Oct., 1931, pages 34-38.

The principle of measuring pressures by thermionic tubes is explained and the new tube described; it consists essentially of a thermionic filament of a 0.004" thoriated tungsten wire, a nickel grid, two electrically connected nickel plates, supporting stem, and bulb with a tabulation for sealing to the apparatus in which the pressure is to be measured. The tube is operated with 120 volts at the anode (electron collector) and – 6 volts at the positive-ion collector. Ha. (2.04)

Flow and Volume (2.05)

A Mechanical Counter for Flow-Measuring Apparatus. (Ein neues mechanisches Zählwerk für Strömungsmessgeräte.) H. Lohmann, *Siemens-Zeitschrift*, Vol. 11, April, 1931, pages 180-187.

The movement of this counter is effected not by a friction gear but by a ratchet which is so arranged that it is in or out of gear for one revolution in proportion to the velocity of the flow of the medium to be registered. Inaccuracies of friction due to concussions or vibration are in this way eliminated. The construction is described in detail and several types of the instrument illustrated. Ha. (2.05)

Controlling Pipe-Line Pumping Stations Automatically. T. D. Williamson. *Machine Design*, Vol. 3, Oct., 1931, pages 41-43.

The equipment and controls necessary in oil pipe-line boosting stations are described. Lights are used to indicate operating conditions and a master control board shows an exact picture of the state and condition of the automatic station. Ha. (2.05)

A E G—Gas Meters. (A E G—Gaszähler.) *A E G—Mitteilungen*, July, 1931, pages 447-449.

A new dry gas-meter with two measuring chambers, a leather diaphragm and valves with instantaneous operation by springs is now being manufactured along with electric meters. A general description of the meter and its testing is given. Ha. (2.05)

Flow of Liquids in Pipes of Circular and Annular Cross-Sections. A. P. Kratz, H. J. Macintire, R. E. Gould. *University of Illinois Bulletin*, Vol. 28, March 17, 1931, pages 5-26.

The objects of this investigation were to determine the relation between friction factor and Reynolds' number for circular and annular pipe and to determine the head loss resulting from the use of standard elbows in pipe lines carrying calcium chloride brine. It could be concluded from the tests that the use of the Reynolds' number affords a means of correlating friction factors over a wide range of conditions and is independent of the fluid used, in channels with geometrically similar cross-sections. In cases where this similarity does not exist this number is not strictly correct but it correlates the friction factor with temperature, velocity of all fluids. Reynolds' number is not applicable for correlating the head lost in elbows but can be used for plotting the data. The loss in head in elbows is largely influenced by the presence of eddies and cross currents rather than surface friction. The method of calculation is illustrated by an example. Ha. (2.05)

Temperature (2.06)

Electrical Temperature Measurement for Special Purposes. (Elektrische Temperaturmessung fur Sonderzwecks.) J. Moeller and O. Hauser. *Feinmechanik und Praezision*, Vol. 39, June 21, 1931, p. 88-91.

A few special types of thermo-couples are described which had to be shaped according to the particular conditions under which the measurement was made, f. i. temperature of surface, liquids in pipes, etc. Ha. (2.06)

The Control of Temperature in Industrial Furnaces. (Ueber die Regelung der Temperatur in industriellen Oefen.) V. Paschkis. *Zeitschrift Verein deutscher Ingenieure*, Vol. 75, Feb. 21, 1931, page 218.

This paper deals with the question: "By what amount must the furnace temperature, if measured without heat inertia, be increased within a definite time in order to obtain in the same time an increase in temperature equal to the insensitivity, if measured with inertia?" The respective characteristics are shown to be equilateral hyperboles; the curve giving the increase of temperature is proportional to the excess of heat for every moment whereby excess of heat equals connected value minus losses minus useful heat. From these considerations an instrument is developed; this method permits the calculation of the changes of regulation differences for changes of the insensitivity and is applicable for all temperature time schedules. Ha. (2.06)

Measuring the Temperature of Flames. *Fuels and Furnaces,* Vol. 9, Jan. 1931, page 32; *Die Messtechnik,* Vol. 7, Oct. 1931, page 267.

In a method used by the Pittsburgh Station of the Bureau of Mines the intensity of the light of a flame which may be hot enough to melt sodium vapor is compared in a spectroscope with the light of a heated solid at known temperature. Maximum flame temperatures vary from 1880° C for methane to 1975° C for ethylene. Maximum calculated temperatures are 40° to 70° C higher for the saturated hydrocarbons and about 100° C higher for the unsaturated hydrocarbons than the experimental values. Radiation losses account for the lower measured temperature. Ha. (2.06)

Automatic Combustion Control Systems for Wire Furnaces. F. Aschner & H. Mayer-Witten. *Wire and Wire Products,* Vol. 6, Nov. 1931, pages 440-441, 446.

As the economy of the process and the quality of the production in the manufacture of wires depends greatly on the uniformity of temperature, the control of furnaces has become of utmost importance. In this article are described automatic controlling systems and the types of regulators used in Germany; full layouts are given and installations illustrated. Ha. (2.06)

Differential Connections for the Measurement of Temperature Differences by Electric Resistance Thermometers. (Differentialschaltungen zur Messung von Temperaturdifferenzen mit elektrischen Wiederstandthermometern.) W. Geyger. *Archiv Elektrotechnik,* Vol. 25, Oct. 12, 1931, pages 711-714.

A few connections are described and their theory developed. Ha. (2.06)

The Use of Pyrometers in the Brass Foundry. (Die Verwendung von Pyrometern in der Messinggiesserei.) G. Wolfe. *Giesserei mit Giesserei-Zeitung,* Vol. 18, Aug. 7, 1931, pages 639-642.

The necessity of supervision of the pouring temperatures for brass is pointed out and the possibilities and types of pyrometers answering this purpose are described. The only satisfactory thermo-couple is that for direct immersion, but no type has yet been developed that does not show a great wear. It is therefore recommended to use bare wires which are simply pressed together and can be easily renewed after burning off. The optical pyrometers have not given satisfaction on account of the surface of the molten metal. Ha. (2.06)

Boiler House Operation Simplified—XVIII: Thermometer Readings. *Engineering and Boiler House Review,* Vol. 45, Aug. 1931, pages 110-111.

A discussion of the methods used to read thermometers inserted in pockets of pipe lines, in particular when the diameter of the pockets is greater than that of the thermometer bulbs and has to be filled with some heat conducting material. Mercury is good up to 670° F; plumbers' metal up to 1000° F; a mixture of 50% potassium nitrate with 50% sodium nitrate is also advantageous for temperatures well above 800° F. Great care must be observed in inserting a thermometer into a hot pocket; it should first be held directly above the pocket a few moments. Directions for filling the pockets with material are added. Ha. (2.06)

A new Optical Pyrometer. (Ein neues optisches Pyrometer.) *Die Messtechnik,* Vol. 7, April 1931, pages 113-114.

The new instrument of Siemens & Halske is a partial radiation pyrometer which has two crossed filaments which are of different materials and have therefore a different brightness at the same current. At a certain temperature the brightness is the same for both filaments. With this temperature the brightness of the body the temperature of which is to be determined is compared. By charging a resistance in parallel to one filament the comparison temperature is changed, and the brightness of the body whose temperature is to be measured is dimmed by a grey-wedge until the filaments disappear in the brightness of the body. The accuracy of the instrument is said to be ± 2° to 3° at its lowest range of 900° C, and ± 8° to 10° at the highest range of 1800° C. The whole is built into a cylindrical housing and the total weight is about 750 g. Ha. (2.06)

Investigations of the Thermopile. (Etude sur les piles thermoelectriques.) J. Chappuis. *Revue Générale de L' Electricité,* Vol. 29, April 18, 1931, pages 615-628.

This study was undertaken with the view of defining exactly the best conditions of application of a thermoelectric cell for the measurement of radiation based on the temperature of the black body. The experiments show that the sensitivity of the thermocouple can be increased considerably by reduction of the pressure in the place where it is located. The electromotive force is with great approximation proportionate to the intensity of radiation, both in air and in vacuum. From the experimental results a theory is developed. Ha. (2.06)

A New Method of Measuring Temperature. *Heat Treating and Forging,* Vol. 16, Oct. 1930, pages 1327-1328.

The principle of this instrument, "Pyrovisor," is the comparison of the intensity of two monochromatic radiations without a known light source. This can be done since the eye perceives two different colors, concentrated in the same spot, as a third mixed color distinctly different from the two component colors if the latter are of practically the same physiological reaction. The instrument has three filters, the adjustment of which can be read on a scale to giving the temperature. The readings are said to be exact to 1%. Ha. (2.06)

The Industrial Measurement of Temperature and Volume. A. Bodd. *The Instrument World,* Vol. 4, Oct. 1931, pages 107-110.

A brief history of temperature measurements and the evolution of pyrometry is given; the arrangement of instruments where quite a number of them for reading and recording are installed, in a central instrument station is recommended. Industrial applications, the placing in proper locations and the care of resistance thermometers is discussed. Ha. (2.06)

Temperature Regulators for Metallurgical Furnaces. (Ueber Temperaturregler an metallurgischen Oefen.) F. Kohler and G. Scheffels. *Siemens Zeitschrift,* Vol. 11, Oct. 1931, pages 448-453.

Describes the electrical connections of a temperature regulator for blast-furnaces, annealing furnaces, and pusher type furnaces. Ha. (2.06)

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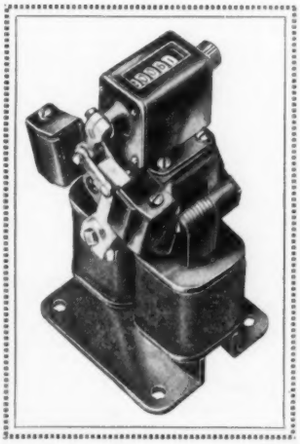

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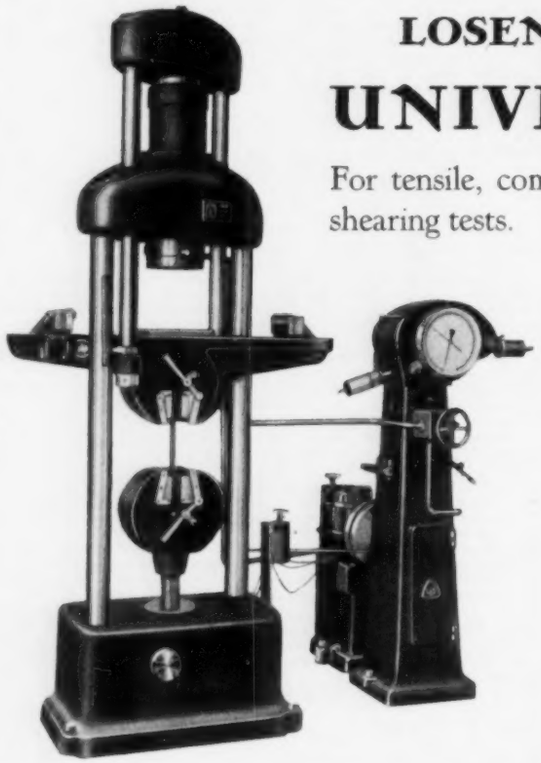

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Vapour-Tension Thermostat. *Electrical Review,* Nov. 6, 1931, page 708.

Describes "Unity" thermostat introduced by Barker, Young & Co., Ltd., London. Designed primarily for controlling tubular-heating installations, and is of the vapor-tension type. MS (2.06)

Temperature Measurement of Molten Cast-Iron. (Temperaturmessungen an flüssigen Gusseisen.) J. Moeller. *Die Messtechnik,* Vol. 7, April 1931, pages 93-96.

After a discussion of the importance of the temperature measurement of the liquid cast-iron the three principal measuring methods are described and compared: thermo-electrical pyrometer, total radiation pyrometer, partial radiation pyrometer; the latter type is considered to be the most practical. As an example for the latter the "Pyropto" of Hartmann & Braun is described. From measurements with an instrument of the latter type the following emission coefficients of iron have been found: iron, solid, polished, 0.45; iron, liquid, bright, 0.40; iron, solid, in air (below 137° C) 0.90; iron oxide 0.90; lead bath (slag) about 1.0; salt baths, about 0.80. These figures give the difference between the radiation of a black body and the not completely black body. A diagram is given from which the corrections for temperatures up to 2000° C can be taken directly. Ha. (2.06)

Recent Advances in Pyrometry. Ezer Griffiths. *Journal Institute of Metals,* Vol. 47, June 1931, pages 1-4.

This review covers recent progress in pyrometry, particularly high-temperature measurements of the melting points of metals. For the calibration of instruments, several points of the International Scale are available: Temperature of freezing zinc, 419.45° C; temperature of freezing antimony, 630.5° C; temperature of freezing copper in a reducing atmosphere, 1083° C; temperature of freezing palladium, 1555° C; temperature of melting tungsten, 3400° C. Thermo-electric recorders and optical pyrometers are described and surface pyrometers and accessory apparatus and a high-frequency furnace for obtaining high temperatures are treated. Ha. (2.06)

Taking Industry's Temperature. D. C. Lamb. *Scovill Standard,* Vol. 4, May-June 1931, pages 8-9.

Some of the methods and instruments for temperature measurements are outlined briefly. Ha. (2.06)

Distance Thermometers for Modern Boiler Plants. G. W. Stubbings. *World Power,* Vol. 16, July 1931, pages 14-15.

The advantages of the resistance method of temperature measurement as applied to boiler operation are (1) fixed temperature datum, (2) great sensitivity, (3) accuracy easily checked; the disadvantages of this method are (1) complicated electrical circuit, (2) external source of current required, (3) costly thermometer coils. The advantages of the thermometer method for the same application are (1) simple electrical circuit, (2) no external source of current, (3) cheap base metal couples can be used; the disadvantages of this method are (1) small E.M.F. only available, calling for sensitive instruments, (2) temperature measured from a non-fixed datum. WAT (9) (2.06)

The Capacities of Emission of Liquid Iron Alloys. (Die Emissionsvermögen von flüssigen Eisenlegierungen.) G. Naeser. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung,* Vol. 12, No. 23, 1930, Report No. 168, pages 365-372; Stahl und Eisen, Vol. 51, Mar. 5, 1931, page 304.

The coefficients of emission of liquid iron alloys were determined between 1350° and 1550° C. Beside the red color generally used, measurements were also taken in yellow and green in order to find out the color that has the smallest deviation from the true temperature. The measurements were taken in a high frequency furnace. The C content does not affect the coefficients of emission. The deviations from the true temperatures are smaller in the green color than in the red color. The results of the measurements in red are in satisfactory accord with previous investigations. GN (2.06)

A New Thermostat. M. V. Polinelly. *Gas Journal,* Vol. 194, June 17, 1931, page 872.

Reviews the paper before Annual Congress of the Association Technique de l'Industrie du Gaz en France, April 21 to 25, 1931. The paper describes the S. D. F. thermostat. It is a vertical tube having its lower end communicating with a deformable metal organ situated in the inlet of the burner and its upper end closed with a screwed plug. An appropriate liquid fills the tube to a suitable height. There is no system of levers, but for all temperatures in the range of the thermostat, the vapor tension of the liquid is below atmospheric pressure. Rise in temperature causes the organ to expand, reducing the flow of gas. On cooling, a vacuum is produced. MAB (2.06)

Heat and Combustion (2.07)

A General Formula for the Heat Transmission of Flowing Liquids in Pipes. (Eine einheitliche Gleichung für den Wärmeübergang stromender Flüssigkeiten in Röhren.) Ten Bosch. *Zeitschrift Verein deutscher Ingenieure,* Vol. 75, Apr. 11, 1931, page 468.

A critical review of tests made by Eagle and Ferguson shows that the results agree very closely with the formula of Prandtl up to 1.5 m./sec. With greater speed, differences occur which become greater with increasing speed. These differences may easily be due to the greater viscosity of the water at lower temperatures because the water was not uniformly mixed for the measurement of the average temperature. The equation, therefore, will give more reliable figures than those derived from the test. Ha. (2.07)

Heat Conductivity Numbers of Plate-Shaped Bodies. (Wärmeleitzahlenplattenförmunger Koerper.) S. Gelius. *Zeitschrift Verein deutscher Ingenieure,* Vol. 75, Mar. 21, 1931, pages 369-370.

First, the influence of the shape of plates used for measuring the heat conductivity was investigated. It is stated that square plates are better for plates of more than 30 mm. while round plates are more suitable for thinner plates, down to 3 mm. The agreement of both types was about 1.5%. The accuracy of measurements is well within the limits permitted in the rules for testing heat and cold insulation equipment. Ha. (2.07)

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An Automatic Flue-Gas (Smoke) Tester. (Ein selbsttätiger Rauchgasprüfer.) H. D. Brasch. *Zeitschrift Verein deutscher Ingenieure*, Vol. 75, Feb. 28, 1931, pages 268.

The instrument is built entirely of metal so that failures due to glass and rubber parts are eliminated. The gas to be analyzed is sent by a mercury pump, alternately, either directly or through an electric furnace into the absorption vessel where CO_2 or CO_2 unburnt parts respectively are absorbed; the remainder of the gas goes into the measuring chamber. The results of these analyses are transmitted by a pendulum to the indicating and recording instrument. The whole apparatus is operated electrically; a full description and illustration is given. Ha. (2.07)

Arrangement of Automatic Firing Control. (Anordnung selbsttatiger Feuerungsregler Bauart A.E.G.-Askania.) *A.E.G.-Mitteilungen*, June, 1931, p. 374-379.

Good adaptability of boilers to fluctuations of load is not sufficient to operate economically at great and sudden fluctuations of steam consumption; this can be achieved only by means of automatic control which must act principally on those parts which determine the efficiency and require so frequent and different adjustment that it can no longer be obtained manually. A few plants are described where the control acts on the gas, powdered coal, and combustion air. Ha. (2.07)

The thermal conductivity of "Eteruit." (Il coefficiente di conducibilità termica dell' "Eteruit.") G. Bozza and I. Secchi. *Giornale di Chimica industriale ed applicata*, Vol. 13, March 1931, p. 212-215.

Eteruit is a heat insulating material of highly compressed cement and asbestos. The very exact experiments which are described in detail gave as heat conductivity 0.45 kcal. per hour per meter length per degree C between 30° and 40° C. Ha. (2.07)

The Specific Heats of Gases at High Pressure. II. Method and Apparatus at High Temperatures. Norman W. Krase & B. H. Mackey. *Journal American Chemical Society*, Dec. 1930, pages 5111-5114.

Presented at the Atlanta meeting of the American Chemical Society, April 9, 1930, before the Division of Physical and Inorganic Chemistry. This paper describes a constant-temperature, adiabatic, flow calorimeter for the measurement of specific heats of gases over the entire range of pressures and up to temperatures of 350 or more degrees. MEH (2.07)

A New Modification of the Adiabatic Micro-Calorimeter. (Une nouvelle modification du microcalorimetre adiabatique.) W. Swietoslawski. *Revue Générale de l' Electricité*, Vol. 29, May 16, 1931, page 786.

The instrument is especially devised for the measurement of the specific heat of solids and liquids. The calorimeter is heated from the outside, and the interior can also be heated by an electric wire. From the readings of the galvanometer connected to a thermocouple in the calorimeter the heat developed can be exactly determined. Ha. (2.07)

Radiant Heating. C. G. Heys Hallett. *Electrical Review*, Nov. 13, 1931, pages 731-732.

Discusses distinction between effective and air temperatures with regard to electric heating of rooms and buildings. Air thermometer is not an adequate guide to comfort and the eupatheostat was developed to meet this need. Autographic recorders installed to watch the performance of the eupatheostat control indicated that there was considerable waste of power in heating due to inadequate guides as to the correct time to switch on the power. A time-switch in which the period of switching on the power is automatically varied by the conditions prevailing at the moment has been developed. This renders it possible to make an installation entirely automatic. A supervisory recorder to detect irregularities in operation is available. The instrument is equipped with two pens operated by similar movements comprising metal bellows directly opposed by helical springs. The bellows operating one pen are connected to a phial below the case, where it records the air temperature. The movement of the other pen is connected to the sphere of the standard radiation thermostat mounted on top of the case. The pressure inside the sphere is a measure of the effective temperature. The two movements are so adjusted that the graduations on the chart represent deg. F. for both pens. The thermostat on top of the case is equipped with its usual contacts, and the instrument can, therefore, be used for controlling the effective temperature as well as a recorder. Ms. (2.07)

Humidity and Moisture (2.08)

Humidity Measurements of Air-Dry Paper Sheets With the Sicometer. (Feuchtigkeitsmessungen an lufttrocknen Papierbahnen mit dem Sicometer.) H. Carsten and C. H. Walter. *Siemens-Zeitschrift*, Vol. 11, May 1931, p. 267-272.

In the manufacture of paper, the humidity contents of the product is of great importance to quality. A continuous supervision of the humidity during the manufacturing process is made possible in a new method of the Siemens & Halske. A.G. which uses the dependence of the dielectric constants of the paper upon its humidity to influence the capacity of a measuring condenser through field of which the paper passes; the siccometer has, therefore, no inertia. The theory of the arrangement considers the paper as a dielectric of several layers; the arrangement of the instrument, calibration and test results are described; continuous recording is possible. Ha. (2.08)

Thermo-Hygrometer. (Thermohygrometer.) L. Scriba. *Die Messtechnik*, Vol. 7, March 1931, pages 63-65.

The instrument uses a thermometer capillary which is controlled by a fine hair, and permits reading the temperature in degrees C., the maximum water content of the air in g/m^3, and the relative humidity of air in percent. It is built by Wilh. Lambrecht A.G., Goettingen, Germany. Ha. (2.08)

Relative Humidity. W. F. Schaphorst. *The Printing Industry*, April 1931, p. 17-19.

Explanation of the meaning of relative humidity and the means of measuring it. The importance of humidity in printing establishments is pointed out. A table of dry and wet bulb temperatures showing relative humidity is given. Ha. (2.08)

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DENSOMETERS

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DRAFT GAGES—see Gages

Work, Power and Output (2.09)

New Torsion Meter for Shaft Energies. (Neuer Torsionsmesser für Wellenleistungen.) H. D. Brasch and A. V. Giebles. *Zeitschrift Verein deutscher Ingenieure,* Vol. 75, March 7, 1931, pages 303-305.

The measurement of energies transmitted by shafts is at first discussed in general and then the new instrument is described which is especially satisfactory with respect to simple manipulation and quick determination. It is based on an acoustic tensiometer. An expanded steel wire is fastened directly to the shaft and measures by its frequency of vibration which is made electromagnetically audible, the tension or torsion of the shaft. In this way a remote measuring is possible or even a supervision of several shafts in a centrally located room. Theory of the method and an example of a long shaft of a steamer is given. Ha. (2.09)

Physical Properties (2.10)

Hardness and Hardness Measurement. (Härte und Härtemessung.) *Report of Laszlo on a paper by Kokado. Zwanglose Mitteilungen duetschen und oesterreichischen Verband für Materialprüfungen der Technik,* Sept. 1931, pages 255-257.

The relations in a sphere-impact test between load and volume of impression, Brinell hardness and angle or impression; further, in the sphere-drop-test, the relation between drop energy and angle of impression and, finally, between rebounding height and angle of impression are all represented as approximately straight lines on 2-axial logarithmic paper. They can be expressed with the same approximation by a formula $y=ai\times xni$; ai and ni are constants of the material. The exponents ni in the various relations of the same material are connected in a simple relation; the constants ai, in a more complicated manner. All these relations are derived by Kokado from a law between tension and plastic upsetting, from which an expression for the degree of hardness is developed. Ha. (2.10)

TESTING AND INSPECTION (3)

Physical Testing and Inspection (3.1)

X-Ray Test Equipment for Materials of the Deutsche Reichsbahn-Gesellschaft in the Welding Laboratory of the Repair Shops Wittenberge. (Rontgenprüfanlagen für Werkstoffe der Deutschen Reichsbahn-Gesellschaft in der Schweisstechnischen Versuchsabteilung des Reichsbahn-Ausbesserungs werkes Wittenberge.) C. Kantner. *Zeitschrift Verein deutscher Ingenieure,* Vol. 75, March 28, 1931, pages 399-400.

The equipment consists of a high-tension apparatus which can produce alternating current with one suppressed half-wave of 120,000 volts, constant direct current of 250,000 volts, and pulsating direct current of 300,000 volts. The apparatus can be dismantled and mounted on railroad cars for tests at other places. Ha. (3.1)

Universal Testing Machine of Low Construction. (Universal prüfmachine niedriger Bauart für 100 t Prüfkraft.) *Zeitschrift Verein deutscher Ingenieure,* Vol. 75, March 8, 1931, pages 302-303.

Short description of a machine for tensile, compression and bending strength with convenient height, 1.6 m., for the work piece and 2.85 m. overall height. Built by Mohr & Federhaff, Mannheim. Ha. (3.1)

Material Testing of Rocks by Sandblast and Introduction of Dynamic Testing Methods. (Werkstoffprüfung von Gesteinen durch Sandstrahl und Einführung dynamischer Prüfverfahren.) E. Gaber & H. Hoeffgen. *Zeitschrift Verein deutscher Ingenieue,* Vol. 75, Nov. 7, 1931, page 1390.

Suggestions are made to make tests by means of the sandblasting machine more uniform and reproducible, and also to compare the materials tested with a standard material. For the latter, mirror glass has been used very satisfactory in the test of the authors. It is recommended just as the importance of dynamic testing has been recognized for metallic materials, also to develop such testing methods for materials used in road building. Ha. (3.1)

Critical Review of Testing Methods for Welded Seams. (Kritische Betrachtung der Prüfverfahren für Schweissnähte.) H. Kemper. *Autogene Metallbearbeitung,* Vol. 23, July 1, 1930, pages 199-205; July 15, pages 218-226; Aug. 1, pages 234-241; Aug. 15, pages 253-258.

A very exhaustive discussion deals with the different methods of testing the quality of a weld. This can be done with destruction of the piece by using the tensile test, bending test, testing at high temperatures, torsion test, impact-notching test, fatigue test, metallographic examinations. Tests which can be made on the finished piece without destroying it are important; they include the judging of quality by the appearance of the weld, electrical testing, magnetic testing and X-ray testing. All these methods and the equipment necessary to their use are described and the results illustrated. Ha. (3.1)

Photoelasticity Assumes Prominent Place in Stress Determination. *Machine Design,* Vol. 3, Nov. 1931, pages 38-39.

The photoelastic method was used to determine the stresses of sheet mill housings and press frames; this resulted in changing the design to a better one of less severe stress concentrations. Several qualities of steel were used in these tests. Ha. (3.1)

Universal Testing Machine for Alternating Fatigue Loads. (Universalprüfmaschine für Dauerwechselbelastung.) K. Rathke. *Zeitschrift Verein deutscher Ingenieure,* Vol. 75, Oct. 10, 1931, page 1289.

A machine of the Lohausenwerk, Düsseldorf, is described for tensile, compression, and bending tests. The material can also be subjected to a pre-stress of any amount beside the alternating load. The reading instruments can be arranged apart and remote from the machine. Ha. (3.1)

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Production Testing and Inspection (3.2)

Specifying Close Limits is Futile Without Suitable Finish. R. E. W. Harrison. *Machine Design*, Vol. 3, Feb. 1931, pages 46-48.

In order to get an objective comparison of the quality of a finished surface, an electro-magnetic type sound detector was used in connection with a loud speaker. Photomicrographs and the sound measurements made it possible to set up a scale for the quality of finish on which a cost diagram could be developed. The proper use of finish can eliminate the often very unsatisfactorily high initial wear. Ha. (3.2)

Torsional Testing of Wire. Alex. Glazunov. *Wire & Wire Products*, Vol. 6, Apr. 1931, pages 130-131, 149-150.

The importance of the torsional test for wires is pointed out as being greater than bending or tensile tests. The following suggestions are submitted: (1) The torsion or twisting test shall be considered as important in the selection of wires for specific purposes. (2) An optional minimum of twists shall be adopted for particular grades of wires. (3) The load under which the number of twists is to be determined shall be expressed in % of the average of the actual tensile strength for each grade of wire under examination. (4) The testing load for torsion shall be conventionally 1, 2 or 3% of the actual tensile strength of the wire. (5) The ruptured end of the tested specimens shall be smooth and the distribution of twists over the entire length of the sample shall be absolutely uniform. A testing machine is described and the convenient dimensions for sample and load proposed. Curves and tables show the relation between load and number of twists until rupture occurs. Ha. (3.2)

Instrument for Measuring Thickness for Continuous Testing of Thin Wires. (Ein Dickenmessgerät zur fortlaufenden Pruefung dünner Drähte.) Samson. *Elektrotechnische Zeitschrift*, Vol. 52, April 16, 1931, pages 512-513.

The wire (for instance thin wires as used in filaments for incandescent lamps) is drawn through a pair of jaws one of which is movable and connected to one of two condenser plates. The plate is moved when the thickness of the wire changes, consequently changing the capacity of the condenser. As the latter is made part of an oscillatory circuit, the change is translated into sound or it can also be recorded. A change of thickness of 1×10^{-4} mm. showed a deflection on the instrument of 0.08 mm. Ha. (3.2)

Testing Installation for Relays. (Relaisprüfeinrichtungen.) F. Fritsch. *A E G-Mitteilungen*, May 1931, pages 327-330.

A few stationary and portable testing arrangements for voltage and current relays, and for relays dependent on load and resistance are described. Ha. (3.2)

A Gear Cutter Comparator. S. Trimbath. *American Machinist*, Vol. 75, Aug. 20, 1931, pages 296-297.

Each side of the cutter tooth is inspected individually; to check the involute, an arrangement is made whereby the rack angle can be determined from a given pitch circle and the involute. The device is described in detail, differences of 0.001 inch can be read. Ha. (3.2)

Measuring Devices in a Railroad Toolroom. *American Machinist*, Vol. 75, Oct. 1, 1931, pages 524-525.

Describes some of the most used gages. Ha. (3.2)

Testing of Hardened Material and Enameled Pieces for Uniformity of Their Hardness, Particularly the Quality of Their Surface by the Ball-Drop Test (Prüfung gehärteter Werkstücke und emaillierter Gegenstände auf Gleichmässigkeit ihrer Härte bez. ihrer Oberflächenbeschaffenheit nach dem "Kugelregen"—Verfahren.) E. Franke, *Oberflächentechnik*, Vol. 7, Aug. 19, 1930, pages 151-153.

Not only the degree of hardness but also the uniformity of hardness is of great, sometimes even greater, importance than the first. The usual test methods of Brinell, Rockwell, by scleroscope, and the scratch method by Martens, do not give a perfect indication as to the uniformity. A new method by Herbert called the ball-drop test, permits testing the whole surface of the piece simultaneously. A great number of steel balls of 3 mm. diameter are dropped from a certain height onto the piece to be tested. With properly adjusted height, dependent on the prescribed degree of hardness of the test material, the test pieces remain perfectly undamaged while those of unsatisfactory hardness or showing soft spots are more or less roughened by the rain of little balls. The roughened places can be clearly recognized on the other smooth ground. The duration of the test lasts 1 to 2 minutes. The same test is very suitable also for enameled pieces; the height from which the balls are dropped is most appropriately about 1 m. to 1.5 m. without injury to the enamel. Several illustrations and a list of 5 references are given. Ha. (3.2)

Using a Ball-Pointed Mike for Internal Thread Measurement. Wm. S. Rowell. *American Machinist*, Vol. 75, July 23, 1931, page 179.

Explains how, from the known geometrical dimensions of balls and micrometer, the internal thread measurements can be easily determined trigonometrically. Ha. (3.2)

The X-Ray Test in the Welding Technique. (Die Röntgenprüfung in der Schweisstechnik.) Kantner. *Die Schmelzschweissung*, Vol. 9, April 1931, page 88.

The advantages of testing of finished materials by X-ray methods is emphasized. In spite of the considerably higher investment costs for an equipment sufficient to penetrate two to three inches of iron, the operating expenses are less than those required for metallurgical or chemical tests; besides no material is destroyed, and what is more, this method is superior to magnetic tests although also this method does not destroy the test piece, because it can be applied also to non-ferrous metals. Ha. (3.2)

Measuring Screw Threads by the Use of Wire. H. L. Van Keuren. *Modern Machine Shop*, Vol. 4, June 1931, p. 40, 42, 44, 46.

Two wires of uniform diameter are laid in two adjacent grooves of the thread and a third one opposite of the two; over these wires the micrometer gage is placed and read. The pitch diameter can then be computed from the formula $PD = M + \cot a/2N - (1 - \text{cosec } a)$, where a is half the angle of thread, N number of threads per inch, M measurement over wires, G diameter of wires. An example illustrates the method; for exact measuring, a set of thread-measuring wires has been made up. Ha. (3.2)

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ELECTRICITY AND MAGNETISM (4)

Electrical Properties, Tests, Measurements and Measuring Instruments (4.1)

The Measurement of Ground Compensation. (Die Messung der Erdschlusskompensation.) E. Hueter and W. Schaffer. *Elektrotechnische Zeitschrift*, Vol. 52, Aug. 1931, pg. 1023-1026.

If in a high voltage system a short circuit between one phase and ground occurs, a current flows through the capacity of the defective phase to ground. This ground current can be compensated by an inductive current. This is effected by an inductance inserted between the star point of the system and ground. It is described in which way these inductance coils can be calculated and adjusted and the currents be measured and the entire diagram of connection for the supervision of the condition of the system is given. The method calls for an auxiliary power transformer the size of which is given by the magnitude of the expected short-circuits and the system voltage. Ha. (4.1)

Copper-oxide Rectifiers. Kartar Singh. *Electrical Review*, Vol. 109, Aug. 14, 1931, pages 247-248.

An element of ordinary copper oxide rectifier is formed by heating a disk of copper about 1/16 in. thick in air or O_2 to approximately 1040° C., whereby cupric and cuprous oxides are formed; the latter is in a liquid state and reacts with the O_2 in the air and the cupric oxide is dissolved in the cuprous oxide. The dissolved cupric oxide appears in the form of crystals embedded in crystals of cuprous oxide and separated from metallic copper by a layer of practically pure cuprous oxide which makes this layer an imperfect dielectric and allows a leakage path to the electrons. This results in a slow discharge of the assymmetrical condenser consisting of metallic copper-cuprous oxide-cupric oxide. The theory of the density of electron flow is developed; the double-wave rectification is described and the action of the copper-oxide rectifier is explained; also explained by the ionic theory. Ha. (4.1)

A New Demonstration Mirror Galvanometer. E. Lowenstein. *Engineering Progress*, Vol. 12, Nov. 1931, page 246.

An instrument designed for demonstration purposes. It is highly sensitive. A shunt is included which, when cut in, increases voltage sensitivity two and a half times and reduces the limiting resistance for aperiodic adjustment to 1% while the current sensitivity drops to only about 50%. The instrument is readily transported. RHP (4.1)

A Bridge for the Measurement of the Conductance of Electrolytes. Paul H. Dike. *Review of Scientific Instruments*, Vol. 2, July 1931, pages 379-395.

A new type of electrolytic conductance bridge is described in detail which has an extreme accuracy for measurements at 20,000 cycles, the difference for instance between measuring a resistance of 10,000 ohms with d.c. and with this bridge being not more than 0.01%. The construction of the resistance-sets and the dial arrangement differs from that of the normal bridge arrangement of Leeds & Northrup. The errors in the bridge due to temperature, humidity, difference between d.c. and a.c. value are all below 0.001%. Ha. (4.1)

A Pendulum Electrometer for High Voltages. (Ein Pendelelektrometer fuer hohe Spannungen.) W. Rogowski. *Archiv Elektrotechnik*, Vol. 25, July 15, 1931, pages 521-522.

The old leaf-electrometer is so modified that the two leaves of very thin aluminum are widened and the edges rounded off in order to prevent glow discharges at high voltages. The two pendulums are suspended on thin wires, one of them carries a scale and the other a finger which gives directly the deflection between the two. Ha. (4.1)

The Physics of the Sliding Contact. II. (Zur Physik des Schleifkontaktes. II.) F. Schroeter. *Archiv Elektrotechnik*, Vol. 25, July 15, 1931, pages 489-496.

The mechanism of current transmission in a sliding contact is experimentally investigated oscillographically with a piezo-quartz. The oscillograms do not reveal any connection between friction and voltage drop at the contact; there exists a fairly solid metallic oxide film which determines the voltage drop. Carbon brushes on carbon rings however, do not show this irregularity. Here the contact resistance depends on the friction. Ha. (4.1)

On the Errors of the Peak-Voltage Measurement by Means of Tube Rectified Condenser Current. (Uber die Fehler der Scheitelspannungsmessung vermittels roehrengleichgerichtetem Kondensatorstroms.) H. Koenig. *Zeitschrift fuer Instrumentenkunde*, Vol. 50, Aug. 1930, page 483.

Brief reference to thesis for Doctor's degree, University of Bern. E.F. (4.1)

A New Galvanometer of Low Resistance and Short Oscillation Period. (Ein neues niederohmiges Galvanometer mit kurzer Einstelldauer.) A. Duebner. *Zeitschrift fuer technische Physik*, Vol. 11, May 1930, pages 163-165.

The new loop galvanometer type exhibits remarkable electric and mechanical advantages in comparison with the standard type according to the writer. E.F. (4.1)

Some Sources of Errors in Thermo-electric Measurements. (Einige Fehlerquellen bei thermo-elektrischen Messungen.) O. Walgert & F. R. Lorenz. *Zeitschrift fuer technische Physik*, Vol. 11, July 1930, pages 242-246.

The paper pertains to the influence of the microstructure of lead wires upon the accuracy of thermo-electric measurements. E.F. (4.1)

Elementary Theory of Electrometers, Particularly of Thread Electrometers. (Elementare Theorie der Elektrometer, insbesonder des Fadenelektrometers.) E. Perucca. *Zeitschrift fuer Instrumentenkunde*, Vol. 50, April 1930, pages 257-267.

The theory is presented and the influence of the connection scheme is discussed. In the conclusion the thread electrometer is compared with the leaf electrometer and the quadrant electrometer. E.F. (4.1)

A Highly Sensitive Tube-Voltmeter. (Ein hochempfindliches Roehrenvoltmeter.) H. Benecke. *Zeitschrift fuer technische Physik*, Vol. 11, Oct. 1930, pages 361-363.

A tube voltmeter with auxiliary alternating EMF. Instrument exhibits a strictly linear calibration curve, and therefore allows measurement of fractions of a milli-volt by means of a needle instrument. The applications of the tube voltmeter in a Wheatstone Bridge are demonstrated. E.F. (4.1)

KILOVOLT AMPERE METERS
KYLYDONOGRAPHS
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Atlas Electric Devices Co.
LACTOMETERS
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Taylor Instrument Cos.
LAUNDER-OMETER
Atlas Electric Devices Co.
LENGTH MEASURING MACHINES
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Gaertner Scientific Corp.
LEVELS
Centering
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Engineer's, Wye, Precision, Prism
R. Y. Ferner Co.
Taylor Instrument Companies
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LOCOMOTIVE INDICATORS
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LUSTER METERS
MACHINE OILS
MAGNETOMETERS
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Hays Corporation
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MASTER CLOCKS
Gaertner Scientific Corp.
MEGOHMMETERS
Illinois Testing Labs., Inc.
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Rubicon Company
MEGOHM VOLTMETERS
Jewell Electrical Instrument Co.
Weston Elec. Inst. Corp.
MELTING POINT APPARATUS
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Tagliabue Mfg. Co., C. J.
METER PROVERS, Gas
METER TESTERS, Gas
MICROMETERS
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Gaertner Scientific Corp.
MICROAMMETERS
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Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Elec. Inst. Corp.
MICROFARADMETERS
General Radio Co.
Jewell Elec. Instrument Co.
Rubicon Company
Weston Elec. Inst. Corp.
MICRO PYROMETERS
MICROSCOPES
Brinell
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Alfred Suter
Measuring
R. Y. Ferner Co.
Metallographic
Bausch & Lomb Optical Co.
Petrographical
Bausch & Lomb Optical Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
MICROTOMES
Bausch & Lomb Optical Co.
MILLIAMMETERS
Bristol Company
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.
MILLIVOLTMETERS
Bristol Company
Brown Instrument Co.
General Electric Co.
Illinois Testing Labs., Inc.
Jewell Elec. Inst. Co.
Rawson Electrical Inst. Co.
Taylor Inst. Companies
Weston Elec. Inst. Corp.
MOISTURE METERS
Tagliabue Mfg. Co., C. J.
MOTOR RADIATOR VALVES
Minneapolis-Honeywell Co.
MOTION RECORDERS
Mechanical
Bristol Company
Foxboro Co.
Baldwin-Southwark Corp.
MOTORS
Bodine Electric Co.
MOTOR GENERATOR SETS
Bodine Electric Co.
MULTIMETERS
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.
MULTIPLE PEN RECORDER
Baldwin-Southwark Corp.
MULTIPLIERS
Jewell Elec. Inst. Co.
Weston Elec. Inst. Corp.
NEON FILLED TUBES
NEPHELOMETERS
OHM METERS
General Radio Co.
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.
OILS
OIL METERS
OIL TESTING APPARATUS
Atlas Elec. Devices Co.
General Electric Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
OPERATION RECORDERS
Electrical
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
ORIFICE METERS
Indicating
Morey & Jones, Ltd.
Indicating & Recording
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
ORSAT APPARATUS
Hays Corporation
OSCILLATORS
Weston Elec. Inst. Corp.
OSCILLOGRAPHS
General Electric Co.
General Radio Co.
Baldwin-Southwark Corp.
OXYGEN RECORDERS
Hays Corporation
Tagliabue Mfg. Co., C. J.
PAINT TESTING INSTRUMENTS
Atlas Electric Devices Co.
PANTOGRAPHS
Gaertner Scientific Corp.
PAPER TESTING INSTRUMENTS
Atlas Electric Devices Co.
PERFORMANCE METER
PERMEAMETERS
Rubicon Company
PAPER TESTING INSTRUMENTS
PERISCOPES
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
PHASE INDICATOR
PHASE SEQUENCE INDICATOR
PHONOGRAPH TURNTABLES, Electric
Bodine Electric Co.
PHOTO-ELECTRIC COLOR ANALYZERS
General Electric Co.
PHOTO-ELECTRIC COLOR COMPARATORS
General Electric Co.
PHOTO-ELECTRIC CELLS
General Electric Co.
Weston Elec. Inst. Corp.
PHOTOMETERS
Gaertner Scientific Corp.
Bausch & Lomb Optical Co.
PHOTO-MICROGRAPHIC EQUIP.
Bausch & Lomb Optical Co.
PHYSICAL TESTING MACHINES
Atlas Elec. Devices Co.
Baldwin-Southwark Corp.
Alfred Suter
PITOT TUBE METER
Brown Instrument Co.
Foxboro Co.
PLANIMETERS
Automatic Flow Record
Brown Instrument Co.
Foxboro Company
Linear
Brown Inst. Co.
Baldwin-Southwark Corp.
Radial
Bristol Company
Foxboro Co.
Square Root
Foxboro Company
POLARISCOPES
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
POSITION RECORDERS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.
POTENTIOMETERS—Indicating
Brown Instrument Co.
General Electric Co.
Rubicon Company
Recording & Controlling
Brown Instrument Co.
Standard Cell Comparing
Eppley Laboratory, Inc.
Feussner Type
Eppley Laboratory, Inc.

Electrical Measuring Devices and Applications (4.2)

Electric-Resistance Strain Gage Measures Stresses in Concrete. E. C. Eaton. *Engineering News Record*, Vol. 109, Oct. 15, 1931, pages 615-616.

The principle of this gage is based on the change in electrical resistance of an elastic steel wire due to change in tension of the wire. A wire of about 300,000 lbs./sq. in. elastic limit and 700,000 lbs./sq. in. breaking strength is used which has a percentage change of resistance of about four times the percentage change of length. The construction of the element is described; after embedding in the cement it is made a branch of a Wheatstone Bridge; changes in length as small as 0.00002 inches or 0.00003 inches can be measured. The compensation for temperature changes is described. Ha. (4.2)

Linear Current Regulation. (Ueber Lineare Stromregelung.) F. Hauffe. *Elektrotechnische Zeitschrift*, Vol. 52, Aug. 13, 1931, pages 1065-1066.

From theoretical considerations combinations of resistances in series are developed which permit an almost linear change of current with the change of resistance. Ha. (4.2)

Developments in Hydrogen-Cooled Rotary Condensers. C. J. Fechheimer. *Electric Journal*, Vol. 28, March 1931, pages 165-169, 178.

Success of the hydrogen-cooled condenser is largely due to the development of many devices for making the machine safe. Features of the machine rendering it safe include: (1) they have been made explosion-proof; (2) an inert gas is used for scavenging, when changing from air to hydrogen or the reverse; (3) the internal pressure is automatically maintained above atmospheric pressure to prevent air entering; (4) various alarm signals are provided to inform the operator should the internal pressure or the percentage of hydrogen be low, or that any part of the machine or auxiliaries is not performing properly; and (5) suitable indicating devices are provided for the gas, water bearings, etc., in addition to the usual electrical instruments. Brief descriptions of these devices are given. Several illustrations and a good bibliography are included. WHB (4.2)

Portable Type Testing Transformers. *Electrical World*, Vol. 97, Mar. 21, 1931, page 564.

Siemens & Halske have marketed testing transformers of laboratory and portable types for obtaining low-voltage d.c. for various test purposes. Applications include use in meter and testing departments of electric light and power companies, in the signal departments of railroads, and in testing and research departments of many industrial establishments. Other applications are: circuit breakers, ammeters, wattmeters, watt-hour-meters and current transformers.
W.H.B. (4.2)

On a New Instrument for Recording Deflections of Single-thread and Double-thread Electrometers. (Ueber einen neuen Apparat zur Registrierung der Ausschlaege von Ein- und Zweifaden-Elektrometern.) O. Mathias & V. F. Hess. *Zeitschrift fuer Instrumentenkunde*, Vol. 50, Aug. 1930, page 484.

Improvements on the Kohlhoerster instrument for registration of altimetric radiations. E.F. (4.2)

Reversing Starter for Small A.C. and D.C. Motors. *Electrical World*, Vol. 97, June 13, 1931, page 1156.

An across-the-line type reversing starter for a.c and d.c. polyphase motors up to 3-hp. has been announced by Cutler-Hammer, Inc., Milwaukee, Wis. They are designed for use with motors on hoists, lifts, garage doors, small machine tools, etc., where a half time intermittent duty reversing starter is required. Reversing is accomplished by means of two mechanical interlocked magnetic contactors which are controlled from a remote point by means of a separate push-button master station. Small size and high operating efficiency are features. The inclosed reversing starters are furnished in two types; one for 2-wire control only, with a maximum capacity of 1 hp.; and the other for either 2- or 3-wire remote control. Blowouts are provided to give maximum capacity of 3-hp. W.H.B. (4.2)

A Compact Lightning Generator for General Testing. F. D. Fielder, *Electric Journal*, Vol. 28, June 1931, page 382.

A new surge generator of light, compact construction and of 700,000 volts capacity can be employed in checking the performances of lightning arresters and grading of substation insulation. The apparatus consists of condensers, the rectifying system, the charging system and all controls. It weighs less than 4,000 lbs., is portable, and can be used either alone or with a cathode-ray oscillograph. W.H.B. (4.2)

A Vacuum-Tube Voltage Regulator. L. C. Verman & L. A. Richards. *Electrical Engineering*, Vol. 50, June 1931, pages 436-438.

A voltage regulator for use on alternators has been developed. Operation involves conversion of a.c. line-voltage fluctuations into corresponding d.c. variations, amplifying these, and applying them to the field of an exciter which supplies the main alternator field, thus controlling the line voltage. A schematic diagram of the regulator circuit is shown; performance tests discussed; and oscillograms presented showing the line voltage, line current, and field current when full load at unity power factor was suddenly applied, and then suddenly dropped, the regulator being meanwhile in operation. W.H.B. (4.2)

Magnetic Measurements (4.3)

Measurement of Magnetic Fields by Means of Electron Rays (Ueber die Ausmessung magnetischer Felder mittels Elektronenstrahlen.) E. Brueche, *Zeitschrift fuer technische Physik*, Vol. 12, Feb. 1931, pages 94-98.

The magnetic field deflects the beam of the electrons and their curvi-linear path is evaluated. Four examples are given, and 8 illustrations. E.F. (4.3)

POWER FACTOR METERS
General Electric Co.
Jewell Elec. Inst. Co.
Weston Elec. Inst. Corp.

PRESSURE RECORDERS
Bristol Co.
Brown Instrument Co.
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Taylor Instrument Cos.

PROCESS TIMING AND SIGNALING INSTRUMENTS
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Tagliabue Mfg. Co., C. J.

PROJECTION LANTERNS
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PROTRACTOR
Optical
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Recording
Bristol Company
Brown Instrument Co.
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Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
Sling
Taylor Inst. Companies

PYRHELIOMETERS—
Weather Bureau Type
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PYROMETERS
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Pyrometer Instrument Co.
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Pyrometer Instrument Co.
Taylor Instrument Companies
Recording
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Pyrometer Instrument Co.
Taylor Instrument Companies
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Immersion
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Brown Instrument Co.
Pyrometer Instrument Co.
Taylor Instrument Companies
Indicating
Bristol Company
Brown Instrument Co.
Taylor Instrument Companies
Recording and Controlling
Bristol Company
Brown Instrument Co.
Taylor Instrument Companies
Surface Contact
Bristol Company
Brown Instrument Co.
Jewell Elec. Inst. Co.
Pyrometer Instrument Co.
Taylor Instrument Companies

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RADIO FREQUENCY OSCILLATORS
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Light Sensitive
Burgess Laboratories, Inc., C. F.
Vacuum Contact
Burgess Laboratories, Inc., C. F.
Vacuum Tube
Burgess Laboratories, Inc., C. F.

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General Electric Co.
Republic Flow Meter Co.

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Rubicon Company

"REV-METERS"
Veeder-Root, Inc.

RHEOSTATS
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Rubicon Company

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Taylor Inst. Companies

SACCHAROMETERS
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SALINITY INDICATORS
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SCALES
Gaertner Scientific Corp.
Alfred Suter

SEISMOGRAPHS
R. Y. Ferner Co.

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SHUNT METERS
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SHUNTS
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.
Rubicon Company
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Republic Flow Meter Co.
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General Radio Co.
Illinois Testing Labs., Inc.
Jewell Electrical Inst. Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

SPECIFIC GRAVITY APPARATUS—Gas
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R. Y. Ferner Co.
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SPECTROSCOPES
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R. Y. Ferner Co.
Gaertner Scientific Corp.

SPECTROPHOTOMETERS
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Gaertner Scientific Corp.

SPEED COUNTERS
Veeder-Root, Inc.

SPEED INDICATORS
See Tachometers

SPEED RECORDERS
Bristol Company
Brown Instrument Co.

STANDARD CELLS
Eppley Laboratory, Inc.
Weston Elec. Inst. Corp.

STOP WATCHES
R. Y. Ferner Co.

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Alfred Suter

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SULPHUR DETERMINATION APPARATUS
Burgess Laboratories, Inc., C. F.
Tagliabue Mfg. Co., C. J.

SUNSHINE RECORDERS
Taylor Instrument Companies

SURGE INDICATORS AND RECORDERS
General Electric Co.

SYNCHRONIZING FORKS—Electrical
General Radio Co.

SYNCHRONOUS MOTORS
Bodine Electric Co.

TACHOGRAPH
Baldwin-Southwark Corp.

TACHOSCOPES
Brown Instrument Co.

TACHOMETERS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Veeder-Root, Inc.
Weston Elec. Inst. Corp.

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Baldwin-Southwark Corp.

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Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

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Alfred Suter

TENSOMETER (Huggenberger)
Baldwin-Southwark Corp.

TESTING MACHINES
Fatigue
Baldwin-Southwark Corp.
Alfred Suter

Magnetic Properties, Materials and Applications of Same to Measurement and Control (4.5)

On a New Method for Determining the Magnetizability of Dynamo and Transformer Sheets. (Eine neue Methode zur Bestimmung der Magnetisierbarkeit von Dynamo- und Transformatorenbleche.) E. SCHRAMKOW & B. JANOWSKY. *Zeitschrift fuer technische Physik*, Vol. 11, June 1930, pages 213-216.

Development of the Gumlich-Rogowski method for measurements of the magnetizability of Epstein-samples.

E.F. (4.4)

ELECTRONICS AND RADIO (5)

Radio Measurements (5.1)

A Meter for Indicating 100% Modulation. G. F. LAMPKIN. *Electronics*, July 1931, page 26.

An arrangement is described by which an indicator tube with reverse connection to the plate supply of the modulated tube indicates accurately 100% modulation. The method of calibrating the set-up is described. Ha. (5.1)

A New Electro-Optic Measuring Method for Voltages and Currents of Very High Frequency. (Ein neues elektro-optisches Messverfahren fuer Spannungen und Strome sehr hoher Frequenz.) L. PUNGS AND H. VOGLER. *Elektrotechnische Zeitschrift*, Vol. 52, Aug. 13, 1931, pages 1053-1056.

Large currents and potentials can not be measured with accuracy at frequencies over 3 x 10^6 Hz by the usual electrometric and thermal methods. A new method is described and theoretically derived which uses the principle of the electro-optic Kerr-effect; the apparatus consists of a source of light, a Nicol-Prism as polariser, a cell with the Kerr-liquid (nitrobenzol or nitrotoluol), and another Nicol-prism as an analyser. The voltage to be measured acts on the cell by means of two condenser plates. If the field of vision is adjusted to dark (by crossing the prisms), the field will become light when the voltage is connected to the condenser. The relation between intensity of light and voltage is given by a Bessel-function and reproduced by a curve. The accuracy of the method is, for voltages from 1000 to 1800, about 0.6 to 0.1%. Six references. Ha. (5.1)

High-frequency measuring instruments. (Hochfrequenz-Messgeräte.) AND. JAUMANN. *Elektrotechnische Zeitschrift*. Vol. 52, June 30, 1931, pages 985-991.

A number of instruments for measurements in the range from 100 to 1500 Hz.; that is, from a wavelength of 3000 to 200m. is described. The sending apparatus, the measuring of voltage with the tube voltmeter, resistance and reactance measurements, condenser loss meter, and a bridge arrangement are described in detail. Ha. (5.1)

Applications of Radio to Measurement and Control (5.2)

The Registration of the Movements of a Gravity Pendulum by Means of High Frequency Oscillations and Their Influence Upon the Pendulum. (Die Registrierung der Schwingungen eines Schwerkraftpendels mittels hochfrequenter elektrischer Schwingungen und ihre Rueckwirkung auf das Pendel.) H. SCHMEHL. *Zeitschrift fuer Instrumentenkunde*, Vol. 50, Dec. 1930, pages 707-708.

The influence upon the gravimetric acceleration is negligible. E.F. (5.2)

Pendulum Registration Device by Means of Capacitative Contacts. (Die Registrierung von Pendelschwingungen mittels kapazitiver Kontakte.) H. MAHNKOPF, *Zeitschrift fuer Instrumentenkunde*, Vol. 50, Dec. 1930, pages 706-707.

The disadvantages of the mechanically operating electric contacts led to improvements outlined in the paper. The movements of the pendulum are recorded by means of high frequency oscillations. E.F. (5.2)

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New Metal for Instruments

(Continued from Page 65)

Illium lends itself well to the precise character of castings required for measurement or control equipment. Castings with walls as thin as ⅛ in. have been produced, although less than ¼ in. is not generally recommended. The metal maintains uniform soundness, with comparative freedom from porosity.

Illium can be plated with chromium and other metals, but this procedure is usually not necessary since Illium itself has a high, non-tarnishing luster when polished. Its appearance is a bluish light gray, resembling steel.

The machining of Illium presents no great problems. It can be turned, milled, planed, bored, threaded, or tapped with either high speed steel or carbide tools. A good grade of cutting lubricant is desirable in finish cutting, and the same general procedure used in the machining of cast steel should be followed.

For high-temperature measuring or controlling equipment this new metal has considerable possibilitees, as the characteristics of Illium with regard to oxidation at high temperatures are often advantageous—the fact being that Illium has no appreciable affinity for oxygen or any other common gas, except wet chlorine, at any temperature below its melting point.

Impact
Baldwin-Southwark Corp.
Alfred Suter
Hardness
Baldwin-Southwark Corp.
Alfred Suter
Portable—Hardness
Alfred Suter
Portable—Tensile—Compression
Baldwin-Southwark Corp.
Alfred Suter
Sheet Metal
Alfred Suter
Baldwin-Southwark Corp.
Torsion
Oil & Bearing
Baldwin-Southwark Corp.
Universal
Baldwin-Southwark Corp.
A. Suter

TEXTILE TESTING INSTRUMENTS
Atlas Electric Devices Co.
A. Suter

THERMIONIC RECTIFIERS
General Electric Co.

THERMO-JUNCTIONS (Electric)
General Radio Co.
Rawson Electrical Inst. Co.

THERMOPILE—Coblenta Type
Eppley Laboratory, Inc.

THERMOMETERS
Gas Filled
Bristol Company
Brown Instrument Co.
Foxboro Company
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
Mechanical
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Mercurial
Bristol Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Resistance
Brown Instrument Co.
Vapor-Tension
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
Wet & Dry Bulb
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

THERMOSTATS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

TIME INDICATORS
Baldwin-Southwark Corp.

TIME METERS
General Electric Co.

TIME OPERATION RECORDERS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.

TIME RECORDERS
Bristol Company
Brown Instrument Co.
Gaertner Scientific Corp.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

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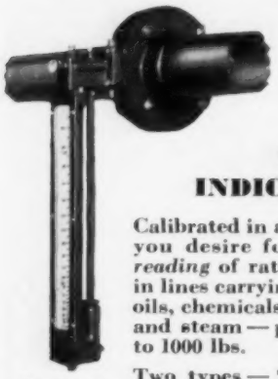

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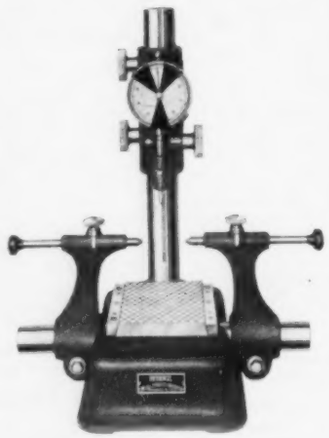

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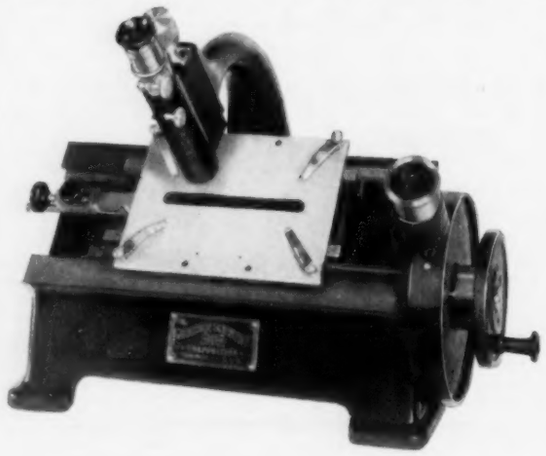

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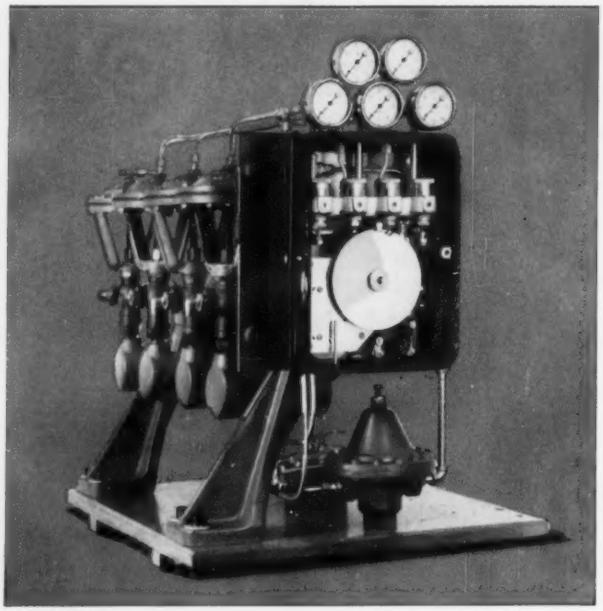

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